Chapter 4

Employment

To effectively employ FA radars, one must understand the technical characteristics of radars, how the radar acquires targets, and the technical requirements for radar employment. FA target acquisition personnel provide the technical expertise required to support radar employment planning by the controlling FA headquarters. TA personnel pay an integral role in the MDMP process thus ensuring that radars are integrated into the operational plan. Once the plan is completed, radar operators exploit the technical aspects of the radars to maximize their effectiveness and enhance survivability.

SECTION I – DETECTION, VERIFICATION, AND LOCATION METHODOLOGY

HOSTILE MODE

Weapons locating radars spend the majority of their time operating in the hostile mode. It is important to understand how the radar acquires and tracks projectiles in flight and extrapolates weapons location from this information. Both the Q-36 and Q-37 operate in the same manner. The radar performs these basic steps to determine a hostile firing location:

- Establishes the search fence.
- Verifies penetration of the search fence.
- Validates the trajectory.
- Tracks the projectile.
- Extrapolates the firing location and determines the impact predict point.

Several conditions must exist for the radar to achieve a solution and provide a weapon location and impact predict point. First, the range to the projectile must be such that the radar beam strikes the object on the ascending branch of the trajectory. In hostile mode, the radar will only detect objects on the ascending branch of their trajectory. Further, the object must also be large enough to create a radar return and its speed must be within the radar's operational parameters for the radar to "see the object". Once the radar sees the object, it determines the trajectory of the object. The object must display a ballistic trajectory or the radar rejects it. Once, the object is detected it must be tracked for sufficient time for the radar to achieve a solution. The amount of track time required to achieve a solution differs by radar type. The required tracking times are:

- Q-36: 3-5 seconds.
- Q-37: 5-8 seconds.

The radar can only determine locations from objects presenting characteristics within the technical capabilities of the radar and that pass through the possible detection area of the radar. It is important to understand the possible area in which the radar can detect an object.

The possible detection area is a three dimensional space defined by the minimum and maximum range, search sector, and the vertical scan of the radar. Planning ranges are used for the purposes of this discussion. However, the maximum planning range for a radar is not an absolute. It is the range at which the probability of detection becomes low enough to be unsuitable for planning purposes. Nonetheless, objects may be detected beyond the maximum planning range. Conversely, objects within the planning ranges may not be detected. Planning ranges for the AN/TPQ-36(V)8 and AN/TPQ-37 are:

- AN/TPQ-36(V)8 – 14.5km for artillery, 18km for mortars, and 24km for rockets.
- AN/TPQ-37(V) – 30km for artillery and mortars, 50km for rockets.

The search sector is the area left and right of the radars azimuth of orientation where the radar can locate targets. The maximum search sector is plus or minus 800 mils from the azimuth of orientation for a total of 1600 mils. The search sector can be narrowed based on the tactical situation. Figure 4-1 depicts a possible search sector and associated range limits.

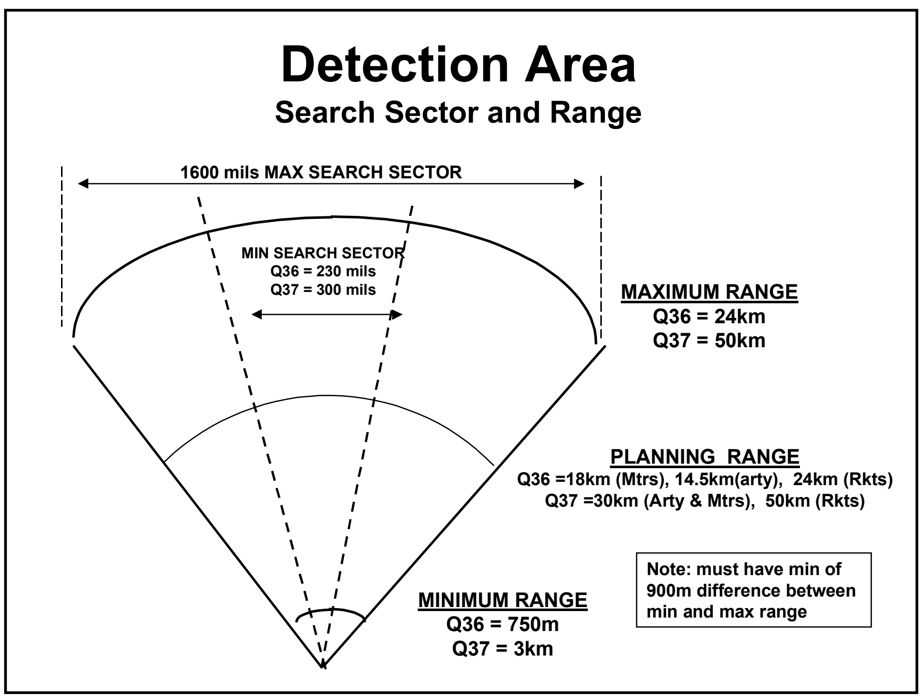


Figure 4-1. Search Sector and Range Limits

The vertical component of the detection area is vertical scan. This area extends vertically from the radar's search fence to the maximum scan elevation of the radar. Figure 4-2 shows the vertical scan capabilities for the

Q-36 and Q-37 radars. The three dimensional area shown in the diagram is the area where an object can be detected and tracked.

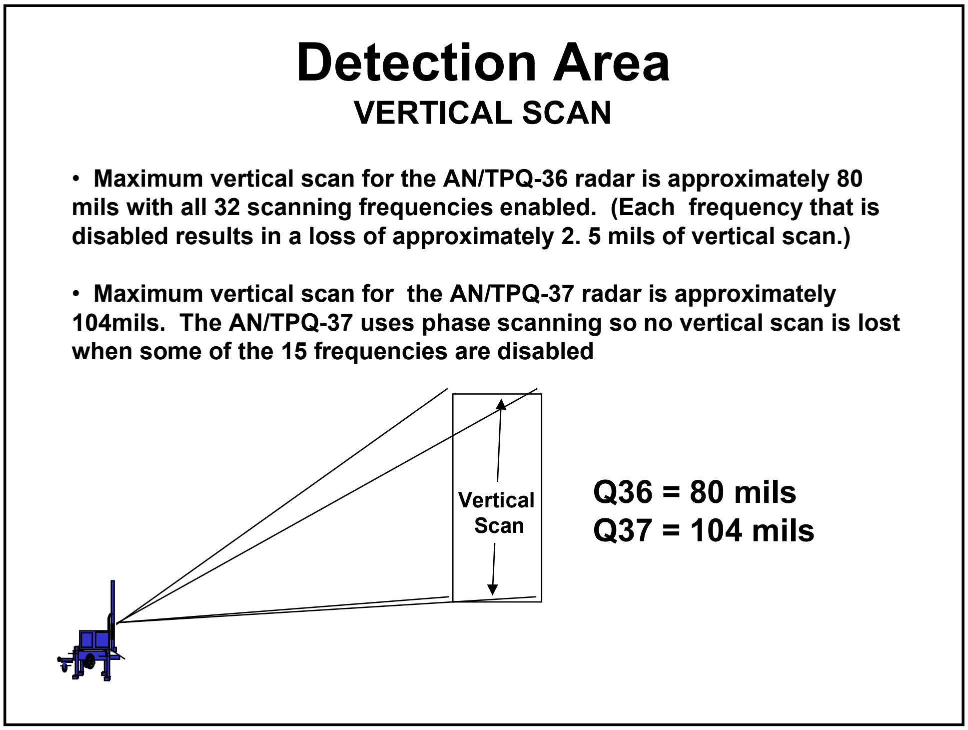


Figure 4-2. Vertical Scan

There must be a sufficient amount of vertical scan at the points where an object passes through the detection area for the radar to track it and compute a solution. The amount of available vertical scan is called track volume. Radars require a minimum of 50 mils of track volume to track a round for long enough to achieve a solution. Figure 4-3 shows the concept of track volume.

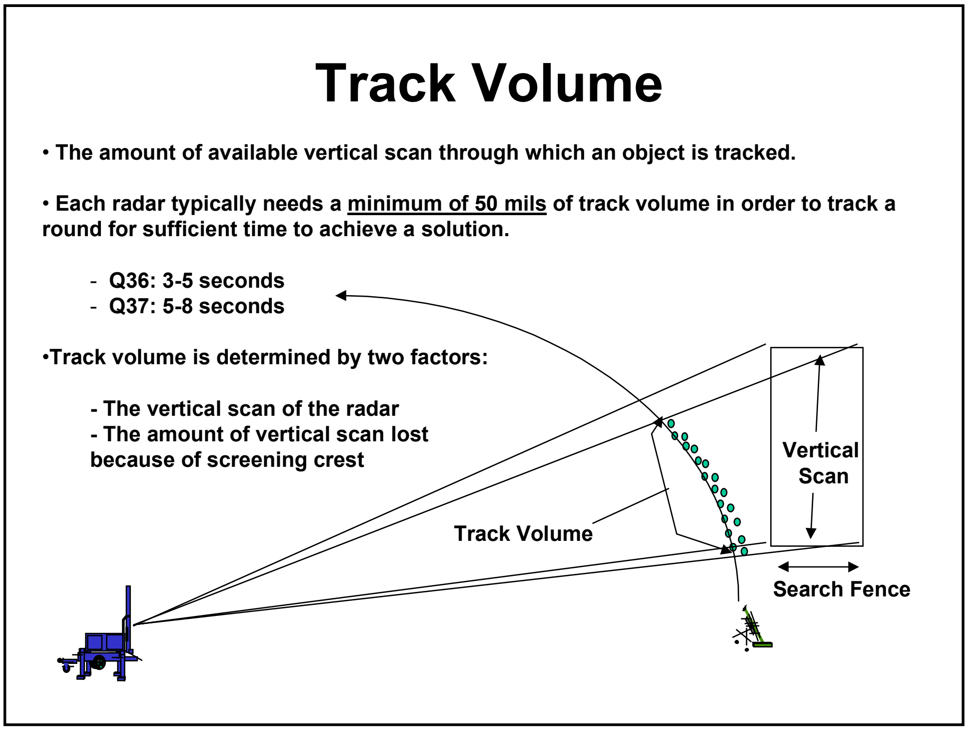


Figure 4-3. Track Volume

There are two other major factors that affect the radar's ability to detect, track and achieve a solution for a target. They are aspect angle and speed of the object. The aspect angle is the angle measured from radar antenna to the target path of the object. The aspect angle must be greater than 1600 mils. This means the object must be traveling toward the radar. Objects with aspect angles approaching 1600 mils may not be detected. The velocity of the object must also be considered. The velocity must be within the minimum and maximum velocity thresholds for the specific radar. Figure 4-4 depicts the concept of aspect angle and Figure 4-5 provides the velocity requirements for the Q-36 and Q-37 radar.

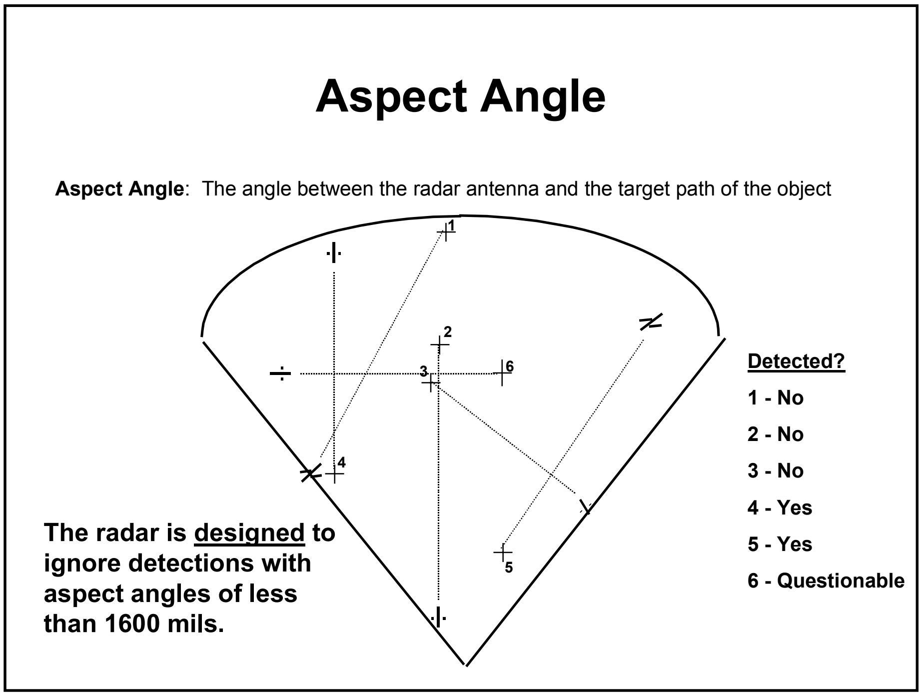


Figure 4-4. Aspect Angle

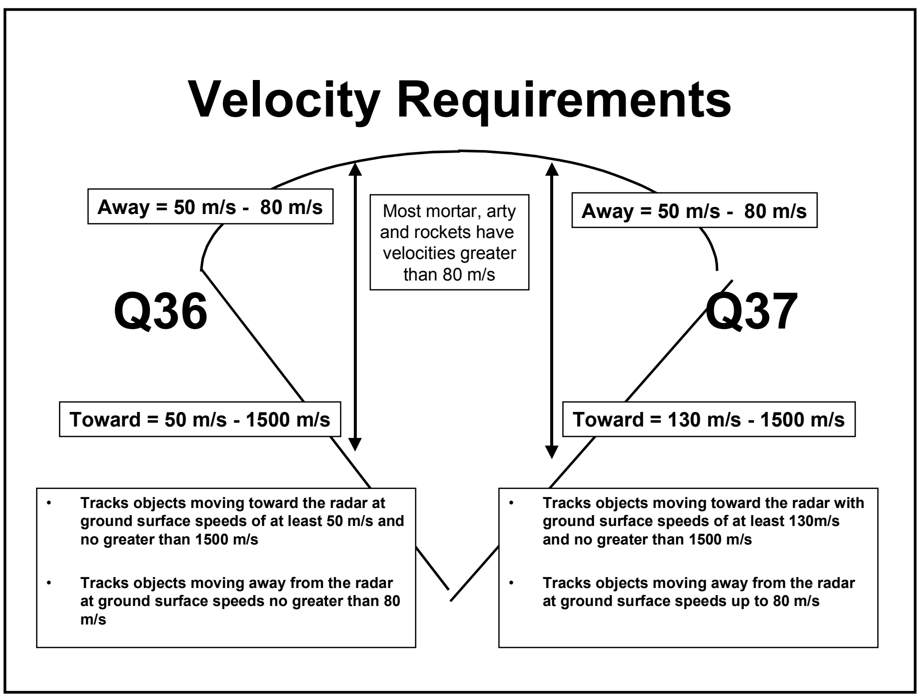


Figure 4-5. Velocity Requirements

DETECTION, VERIFICATION AND LOCATION PROCESS

Establishing the search fence is the first step performed by the radar for detecting an object. The radar accomplishes this by transmitting a series of beams that conform to the terrain. Once an object penetrates the search fence, the radar determines the objects speed, elevation, range and azimuth. The radar uses this information to predict the object's next location and to send out verification beams to determine if the object has a ballistic trajectory.

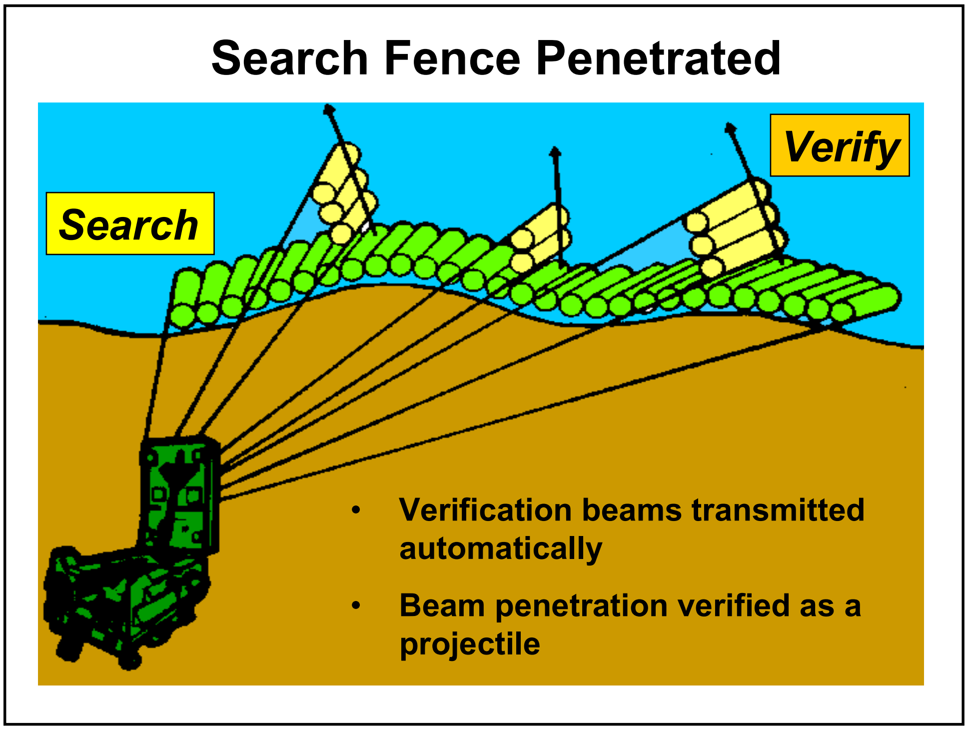


Figure 4-6. Object Verification

If a ballistic trajectory is verified, the radar sends out a series of tracking beams. These beams provide the radar with the information required to mathematically extrapolate a predicted launch and impact point. The radar stops sending out tracking beams when the following conditions exist:

- A solution is computed for the acquisition.
- Three sequential misses happen for the Q-36 or five sequential misses for the Q-37.
- The predicted azimuth for the next track update is outside the left or right limit of the radar' search sector.
- The predicted elevation of the next track is above or below the radar's minimum or maximum search elevation.

Figure 4-7 depicts how an object is tracked.

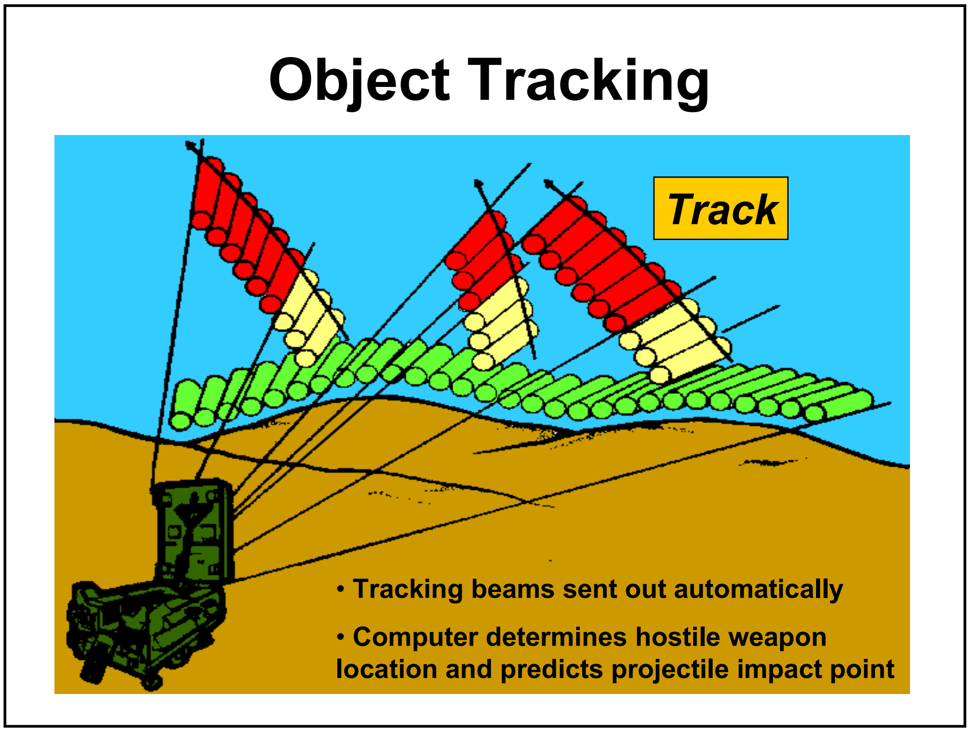


Figure 4-7. Object Tracking

THE RADAR BEAM

To completely understand how the radar functions one must understand the structure of the radar beam and how the radar uses the beam to track an object traveling through the detection area. A radar beam is actually composed of four individual beams that comprise a track cluster. We normally refer to this track cluster simply as a radar beam. Figure 4-8 shows a cross section of a radar beam.

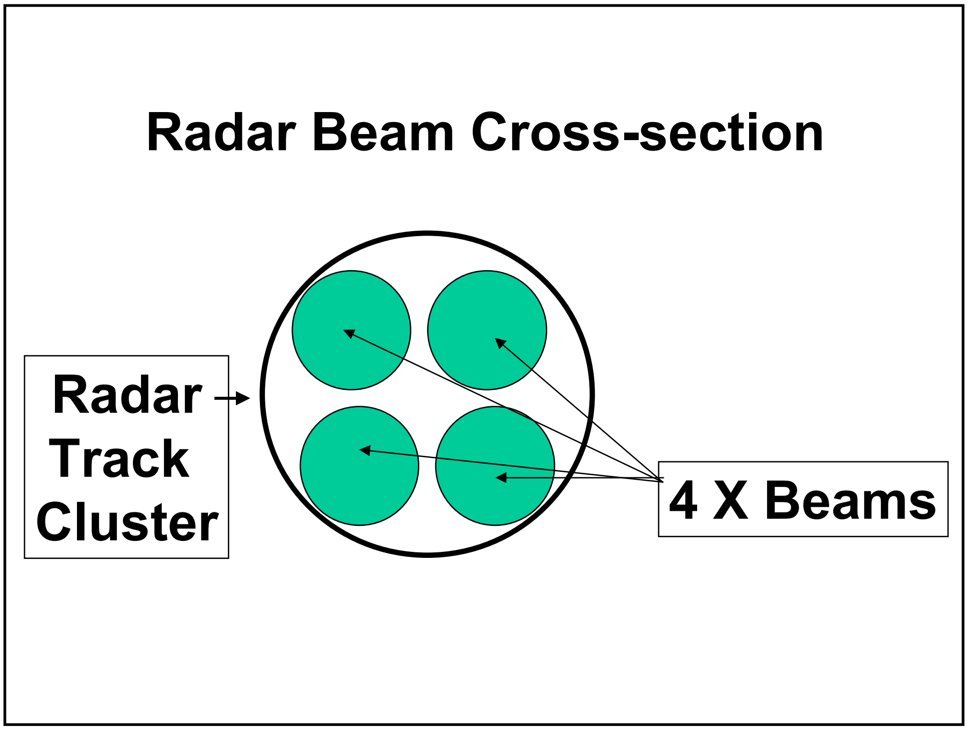


Figure 4-8. Radar Beam

There are three possible outcomes when an object passes through the search fence and the radar transmits a verification or tracking beam. The outcomes are miss, hit, or plot. A miss occurs when the projectile strikes none of the individual beams in the track cluster. A hit occurs when at least one beam in the track cluster is struck, but not all. A plot occurs when the following conditions occur:

- All four beams of the track cluster detect the object.
- The detected range of the object is within 75 meters of the predicted range.
- The detected azimuth is within 20 mils of the predicted azimuth for the Q-36 or 15 mils for the Q-37.
- The detected elevation is with 15 mils of the predicted elevation for the Q-36 and 10 mils for the Q-37.

When the radar achieves an adequate number of plots it computes a solution for the weapons location and impact predict point. The number of plots required to achieve a solution varies based on radar type, initial detection range and the tracking time. In general, the Q-36 needs between 3-15 plots depending on the reasons for track termination. The Q-37 requires 5-12 plots at ranges less than 30 km and a minimum of 15 plots at ranges greater than 30 km. Figure 4-9 summarizes the tracking process.

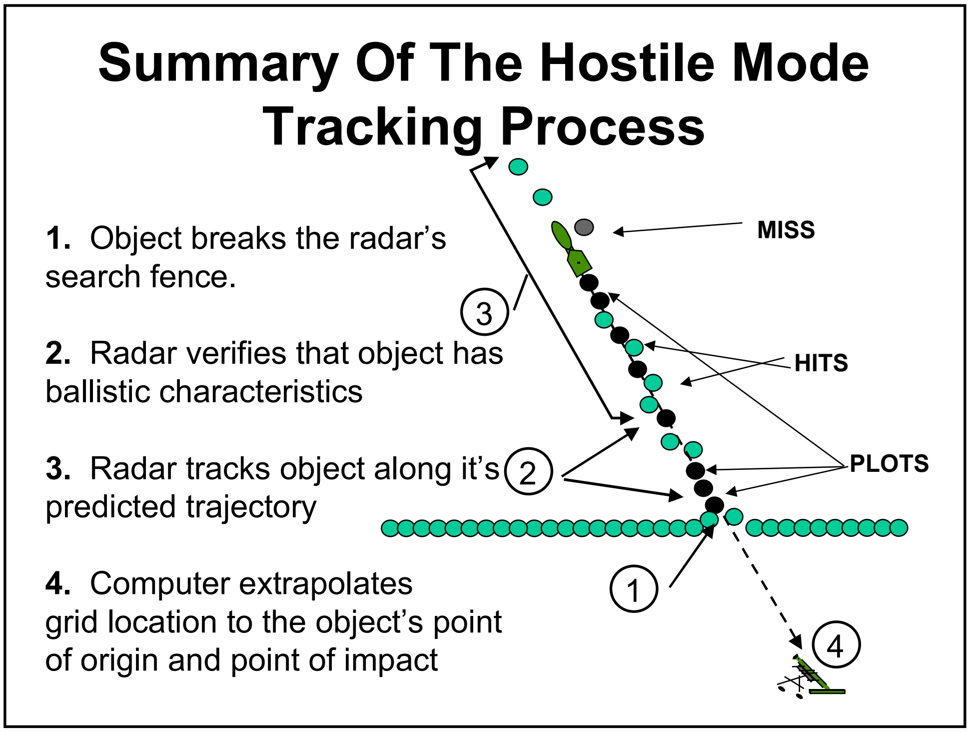


Figure 4-9. Tracking Process

FRIENDLY MODE

The methodology used by the radar to detect, track and determine an impact or burst location in the friendly mode is the same as that for the hostile mode. The major differences are the size of the search fence, angle-T and orientation of the radar. In friendly mode the radar tracks projectiles as they travel away from the radar. Therefore, the radar detects and tracks the projectile on the descending leg of its trajectory. The detection area in the friendly mode is significantly smaller since the search sector must be narrowed to approximately 440 mils. Finally, angle-T, the angle formed by the radar and gun-target lines, must be between 800 and 1200 mils. A detailed discussion of friendly fire mode procedures is contained in Appendix C.

SECTION II – RADAR SYSTEM CHARACTERISTICS

MISSIONS

The primary mission of AN/TPQ-36 and AN/TPQ-37 weapons-locating radars is to detect and locate enemy mortars, artillery, and rockets quickly and accurately enough to permit immediate engagement. Their secondary mission is to observe registrations and help the FDC adjust fire for friendly artillery units. The secondary mission should be performed only when absolutely necessary. Radiation time should be reserved for the primary mission.

AN/TPQ-36(V)8

The AN/TPQ-36 is optimized to locate shorter-range, high-angle, lower velocity weapons such as mortars and shorter-range artillery. It can also locate longer-range artillery and rockets within its maximum range. For mortars and artillery, the higher probability of detection extends to approximately 14,500 meters for artillery and 18,000 meters for mortars. Rockets can be detected with reasonable probability out to 24,000 meters. Minimum and maximum detection ranges can be established; however, at least 900 meters difference in maximum and minimum ranges is required. The radar's antenna electronically scans a horizontal sector from 230 mils to 1,600 mils in width. The Q-36 can search up to 6,400 mils by using the extended azimuth search function. With extended azimuth search, the computer automatically traverses the antenna from two to four positions and performs its target location functions.

The AN/TPQ-36(V)8 can be emplaced and ready for operation within 9 1/2 minutes with a crew of four and can be march-ordered within 4 1/2 minutes during daylight hours. (Emplacement and march-order times do not include the time needed to set up or take down camouflage nets.)

TARGET CLASSIFICATION

Q-36 legacy systems classify acquisitions as three distinct target types. The types are artillery, mortar or unknown. Both cannons and rockets are classified as artillery. The probability of a correct target classification is 90%. The Q-36 does not classify targets by subtype. Therefore, mortar targets are classified as mortar/unknown and artillery targets are classified as artillery/unknown. The unknown target type is interpreted differently depending on whether the receiving device is an initial fire support automated system (IFSAS) or AFATDS. The unknown target will default to target type personnel/unknown in IFSAS and target type terrain/feature in AFATDS.

The Q-36(V)8 radar has the added capability of classifying acquisitions as rockets. However, like Q-36 legacy systems. it does not classify targets by subtype.

PROBABILITY OF LOCATION

The probability of location varies based on target type, range, quadrant elevation, and number of projectiles being simultaneously tracked. Other factors that may affect probability of location are target elevation above the mask, wind velocity, precipitation and the electromagnetic spectrum. In general, the Q-36 can locate up to ten simultaneously firing weapons with quadrant elevations greater than 300 mils without degradation in location probability. This holds true as long as no more that two projectiles are being tracked or new firings do not occur at ranges greater than 7500 meters from acquisition being processed. When both of these conditions occur, the probability of location may decrease by as much as 55%. Wind, rain and electromagnetic countermeasures do not degrade the performance of the radar when the following conditions exist:

- Winds do not exceed 35 miles per hour.
- Rain does not exceed 2 millimeters per hour.
- When a 100-watt ground based emitter's radiation is separated by five or more beam widths from the radar azimuth.

The probability of locating a mortar projectile is 90% or greater at ranges from 3000-18,000 meters over the center 1067mils of the radar's search zone. Outside the center zone the 90% location band is from 3000-15,000 meters. For ranges from 750-3000 meters the probability of location decreases from 90% to 45% in a linear fashion based on range.

The probability of locating cannons is 70% or greater for all ranges between 3,000 and 14,500 meters over the center 1067 mils of the radar's search zone. Outside the center zone the 70% location band is from 3,000 to 11,500 meters. Figure 4-10 shows the higher probability coverage areas for mortars and artillery.

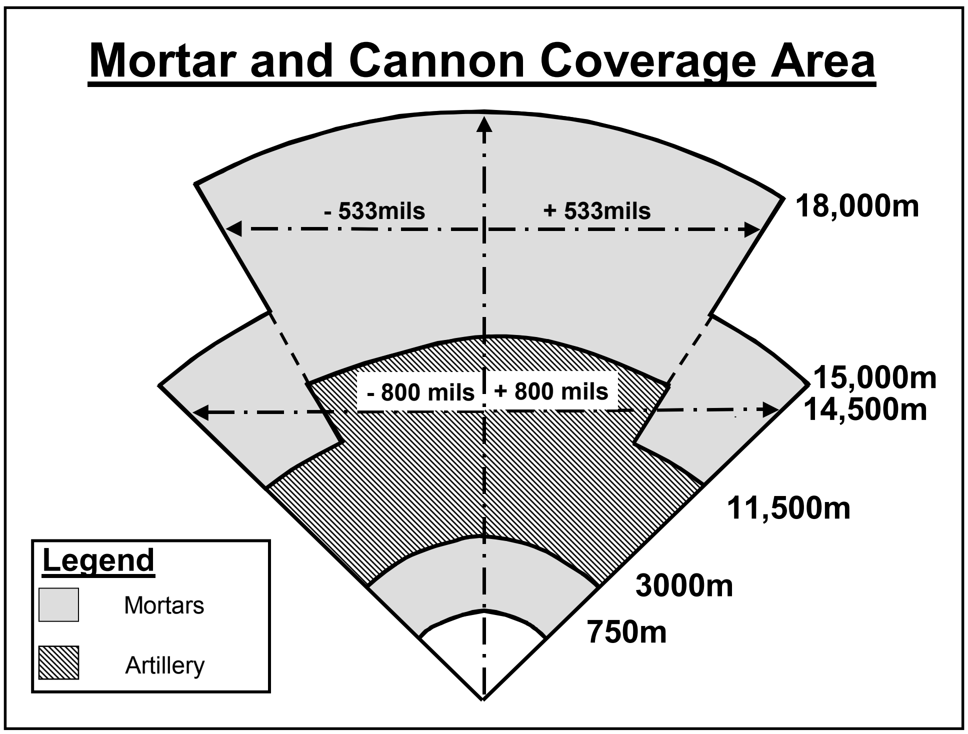


Figure 4-10. Q-36 Mortar and Cannon Coverage Areas

Finally, the probability of locating rockets is at least 80% across the entire radar sector for all ranges from 8,000-24,000 meters. As previously discussed the target will be categorized as artillery. The range to the target and the results of IPB will likely be the only indicator that a target is a rocket. Figure 4-11 depicts the coverage area for rockets.

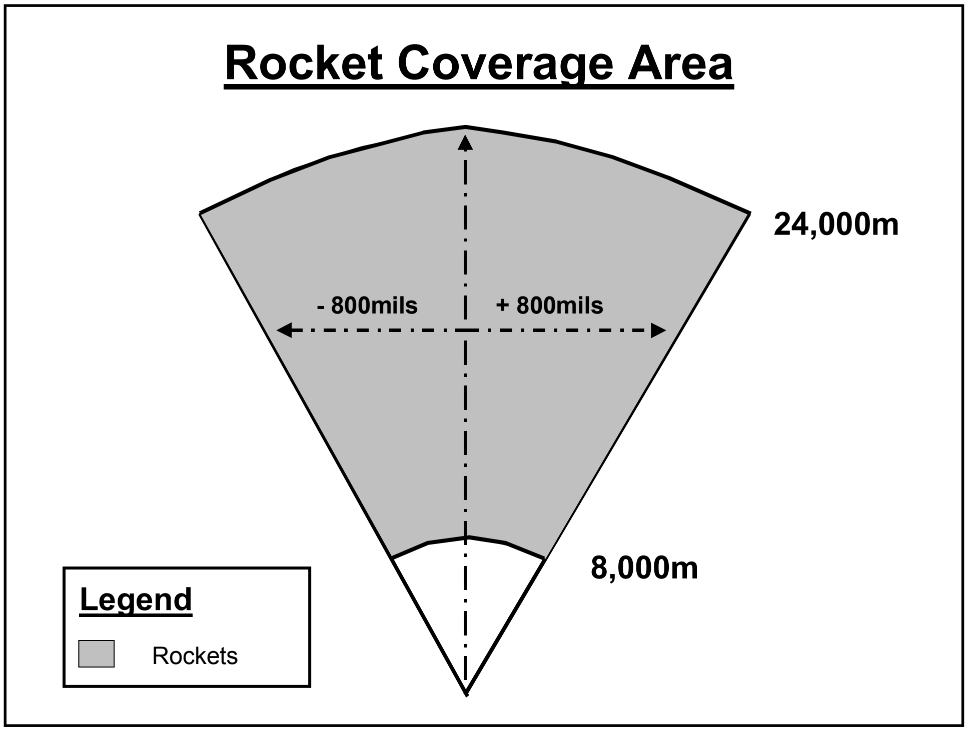


Figure 4-11. Q-36 Rocket Coverage Area

ACCURACY

The accuracy, or target location error (TLE), is generally characterized as the percentage of locations computed that are within a certain distance of the actual firing location for a specific type of projectile. TLE is generally characterized as the radius in meters from the actual weapon locations that 90% and 50% of the computed weapon locations would be located. TLE is an important factor in determining the method of target attack. The maximum 50% TLEs by projectile type are:

- Mortar – 40m or .4% of range whichever is greater.
- Cannon – 65m or .65% of range whichever is greater.
- Rocket – 120m or 1% of range whichever is greater.

The maximum 90% TLEs by projectile type are:

- Mortar – 100m or 1% of range whichever is greater.
- Cannon – 150m or 1.5% of range whichever is greater.
- Rocket – 300m or 2.5% of range whichever is greater.

Table 4-1 provides 50% TLE data and Table 4-2 provides 90% TLE data.

Table 4-1. Maximum 50% Target Location Errors

Target Category	3km	5km	8km	11km	14km	15km	18km	24km
	Ranges							
Mortar	40m	40m	40m	44m	56m	60m	72m	
Cannon	65m	65m	65m	72m	91m			
Rocket			120m	120m	140m	150m	180m	240m

Table 4-2. Maximum 90% Target Location Errors

Target Category	3km	5km	8km	11km	14km	15km	18km	24km
	Ranges							
Mortar	100m	100m	100m	110m	140m	150m	180m	
Cannon	150m	150m	150m	165m	210m			
Rocket			300m	300m	350m	375m	450m	600m

SYSTEM COMPONENTS

The AN/TPQ-36(V)8 consists of an operations control group (OCG), antenna transceiver group (ATG), equipment trailer group (ETG), remote control display terminal (CDT), power distribution group (PDG), trailer mounted auxiliary generator, and a M998 HMMWV for transporting the auxiliary generator trailer. Figure 4-12 depicts the complete AN/TPQ-36(V)8 system.

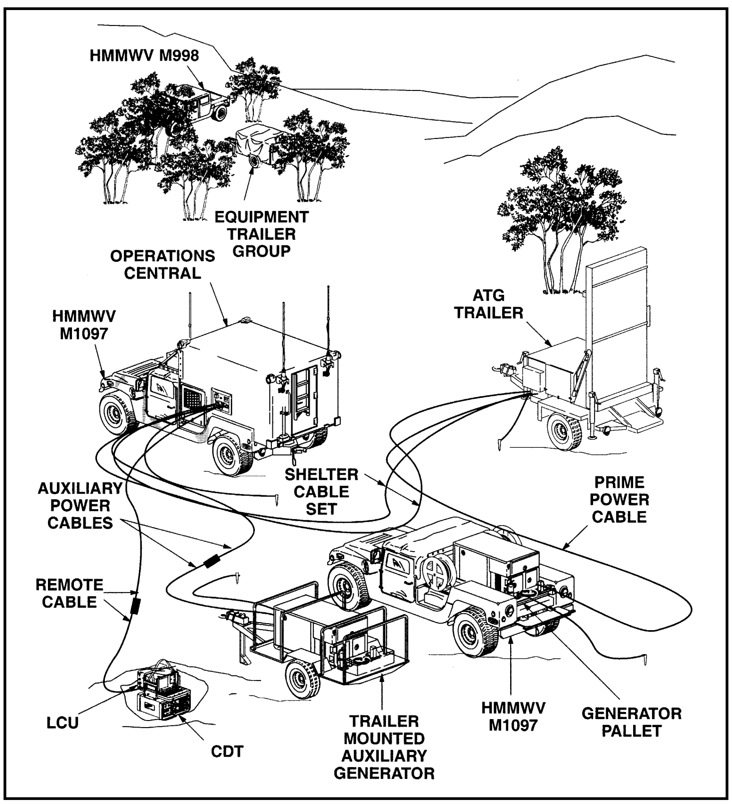


Figure 4-12. The AN/TPQ-36(V)8 Radar System

Operations Control Group

The OCG is the focal point for operating the radar. It consists of a lightweight multipurpose shelter (LMS), a M1097 HMMWV, and the vehicle cab control console (VCCC). The LMS houses the operations central (OC), which controls radar operations. The LMS consists of a paper map display, two operator control stations (OCS), a radar signal processor, two environmental control units, a gas particulate filter unit, a remotable control display terminal (CDT), a line printer and communications equipment. Each OCS consists of a LCU and a color monitor. During normal operations, the right OCS is used to control the radar set. The left OCS is used for planning and as an alternate control console. The communications equipment contained in the shelter consist of the EPLRS and remote devices to control the two SINCGARS radios contained in the ATG. The VCCC contains equipment for remote control of communications, site selection, and location reporting operations from the HMMWV cab. It contains the connections for a removable LCU that allows these functions to be performed during movement. Figure 4-13 shows the operations control group.

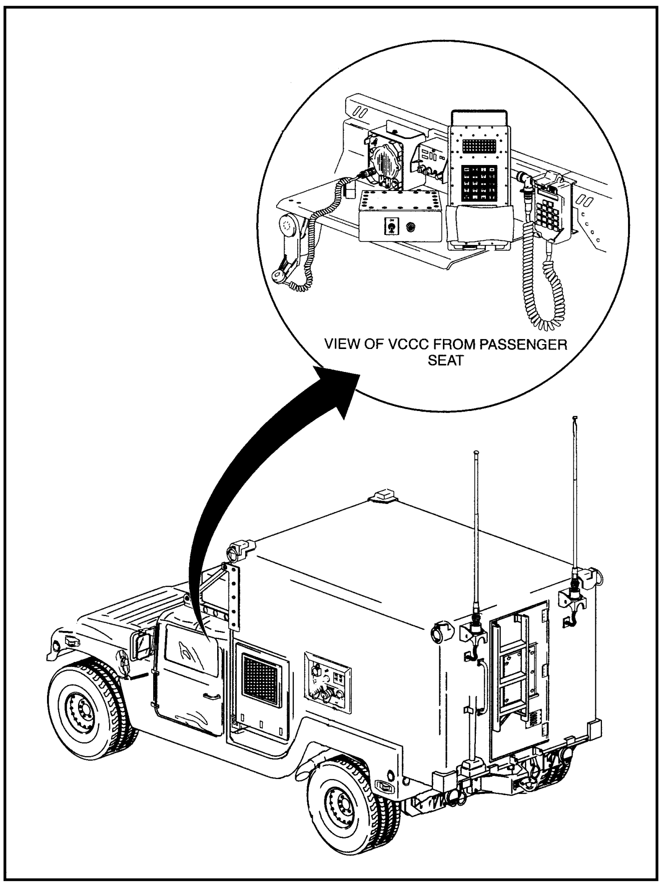


Figure 4-13. Operations Control Group

Antenna Transceiver Group

The ATG consists of the antenna, antenna trailer and all of the radiating elements and associated feed, tilt sensor, beam steering unit, and boresight telescope assembly. The antenna is erected to the vertical position during operations and lowered to the horizontal position for transport. The OCG HMMWV transports the ATG. Figure 4-14 depicts the ATG.

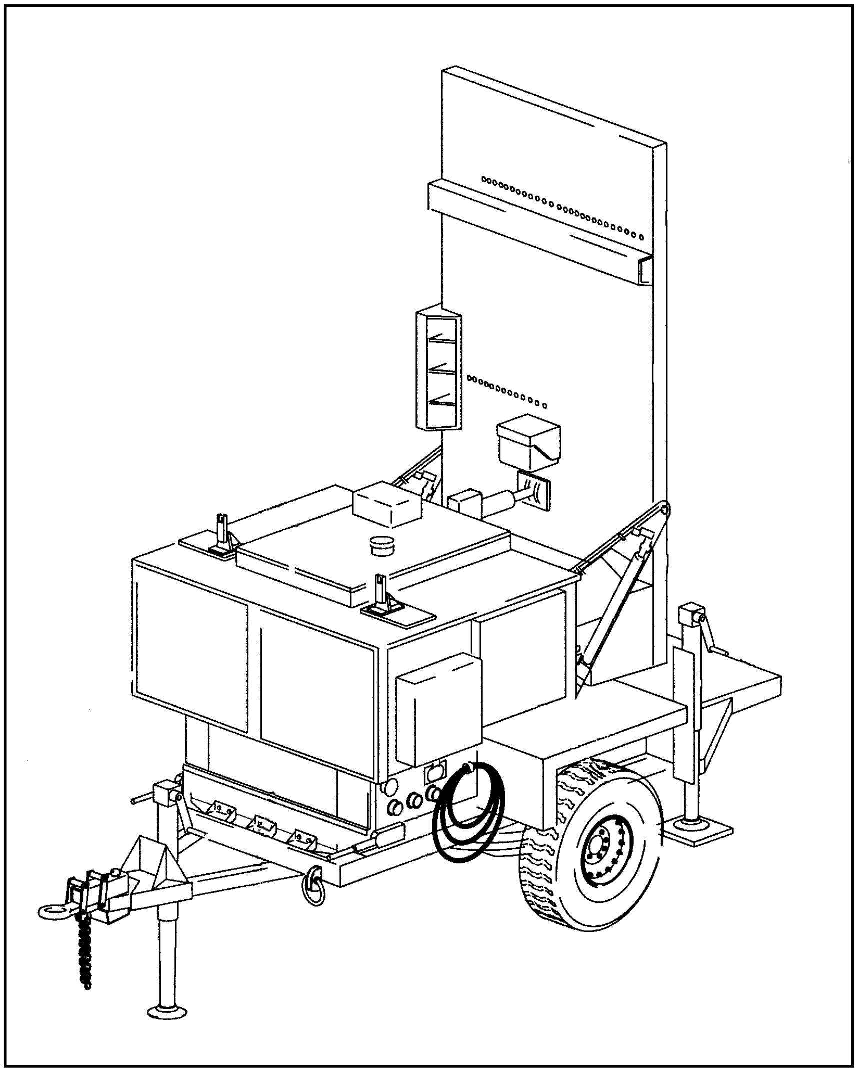


Figure 4-14. Antenna Transceiver Group

Equipment Trailer Group

The ETG consists of a modified M116A3 trailer that provides storage and transport of section equipment. The ETG contains four cable spools. The two upper center cable spools contain two 50-meter remote CDT cables. These cables connect the remote CDT to the ATG shelter. The two lower outside spools contain the shelter cable set. The shelter cable set consists of a 50-meter prime power cable that provides power from the ATG to the shelter and a 50-meter data cable that provides signal interface between the ATG and the shelter. Refer for Figure 4-15 for cable locations.

During movement, the ETG is towed by the M1097 that contains the primary generator pallet.

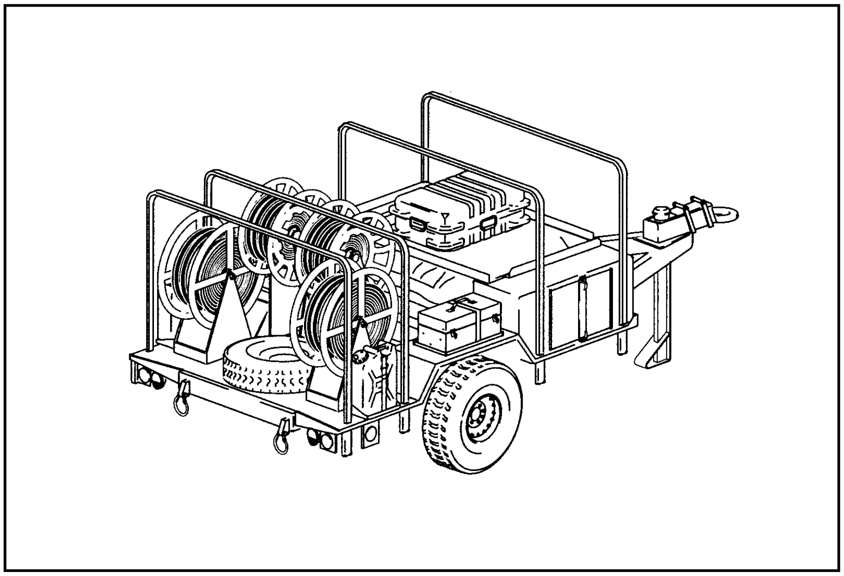


Figure 4-15. Equipment Trailer Group

Remote Control Display Terminal

The remote CDT consists of a LCU and a CDT and permits the remote operation of shelter components. The CDT is normally stored in its case inside the shelter until required for operations. It is removed for use along with one of the LCUs from inside the shelter. Normally the left LCU is removed from the shelter. The CDT can be remoted up to 90 meters from the shelter using the remote CDT cables stored on the ETG. This allows the required 10 meters of slack in the cables. Figure 4-16 shows the configuration of an operational remote CDT.

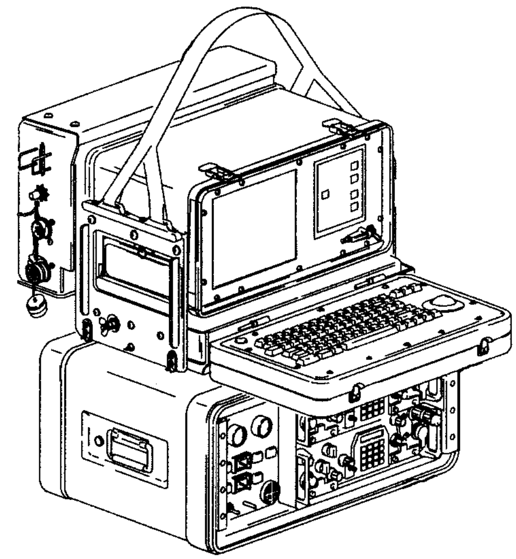


Figure 4-16. Remote Control Display Terminal

Power Distribution Group

The power distribution group consists of generator pallet mounted on a M1097 HMMWV, and the prime and auxiliary power cables. The generator is a 400HZ 10KW precise power generator mounted on a special pallet. The prime and auxiliary power cables are contained on two spools that are mounted on either side of the generator pallet. The prime power cable is a 40-meter cable that connects the PPG generator to the ATG. The auxiliary power cable is a 40-meter cable that connects the auxiliary generator to the shelter. This allows the operation of the second air conditioner contained in the shelter. Figure 4-17 depicts the PPG.

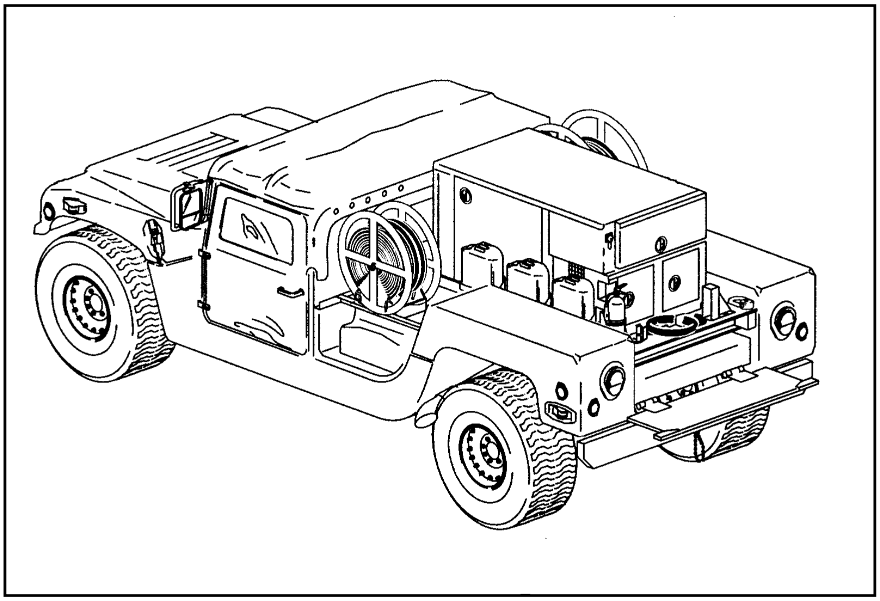


Figure 4-17. Prime Power Group

Trailer Mounted Auxiliary Generator

The trailer mounted auxiliary generator is a PU-799 or 400HZ 10KW generator mounted on a M116A2 trailer. The trailer is towed by the M998/M1038 utility HMMWV during movement. Figure 4-18 shows the trailer mounted auxiliary generator.

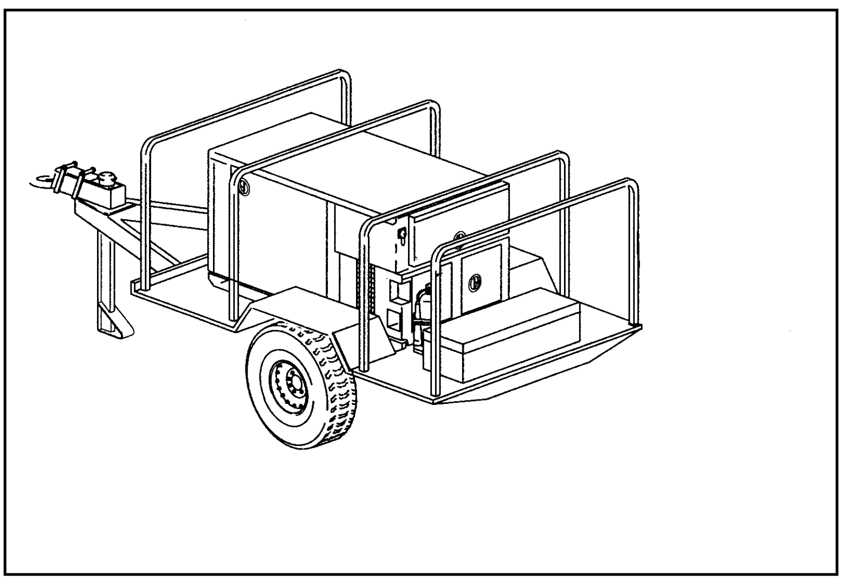


Figure 4-18. Trailer Mounted Auxiliary Generator

AN/TPQ-37

The AN/TPQ-37 is a phased-array artillery locating radar system designed to detect mortars artillery and rockets. The Q-37 is optimized to locate longer-range, low-angle, higher velocity weapons such as long-range artillery and rockets. However, it will also locate short-range, high-angle, lower velocity weapons thus complementing the AN/TPQ-36. The Q-37 has a minimum range of 3 kilometers and a maximum range of 50 kilometers. For artillery, the higher probability of detection extends out to approximately 30 kilometers. Minimum and maximum detection ranges can be established for the Q-37. However, there must be at least 900 meters difference in maximum and minimum ranges.

The Q-37 sector of search is from 300 mils to 1,600 mils. Although the Q-37 is not equipped with the extended azimuth search function, the antenna can traverse a full 6400 mils. The Q-37 is normally deployed 8 to 12 kilometers behind the FLOT and can be emplaced and ready for operation within 30 minutes and march-ordered within 15 minutes during daylight hours. (Emplacement and march-order times do not include the time needed to set up or take down camouflage nets.)

TARGET CLASSIFICATION

The Q-37 classifies acquisitions as three distinct target types. The types are artillery, mortar or rocket/missile. The Q-37 does not differentiate subtypes for these target types. The subtypes default to unknown. The target classifications generated by the Q-37 for transmission to IFSAS/AFATDS are MORT/UNK, ARTY/UNK and RKTMSL/UNK. The algorithm used to locate mortars is a post-fielding software patch designed to provide an addition capability for operation needs. The mortar functionality has not been fully tested so probability and accuracy data is not available. The acquisition ranges for mortars are the same as the ranges for artillery.

PROBABILITY OF LOCATION

The factors affecting the Q-37's probability of location are the same as for the Q-36. In general, the Q-37 can locate up to ten simultaneously firing weapons with quadrant elevations greater than 300 mils without degradation in probability of location. This is true when no more that two projectiles are being tracked or new firings do not occur at ranges less than 6,000 meters or greater than three-quarters of the specified range for a specific projectile type. When both of these conditions occur, the probability of location may decrease to a probability of detection no lower than 50%. Wind and rain do not degrade the performance of the radar when the following conditions exist:

- Winds do not exceed 40 miles per hour with gusts to 75 miles per hour.
- Rain does not exceed 5 inches per hour with horizontal wind gusts of 40 miles per hour.

The probability of locating a cannon projectile is 85% or greater at ranges from 4,000-30,000 meters when weapon quadrant elevations are greater than

200 mils at ranges less than 10,000 meters and 300 mils at ranges greater than 10,000 meters. The ranges vary depending on the size of the projectile. The range fan for detecting light cannon is from 4,000 to 20,000 meters over the entire search sector. For medium cannon, the range fan is from 4,000 to 25,000 meters over the center 1067 mils of the search sector and 4,000 to 20,000 meters over the outside sector of the search sectors. The range fan for heavy cannon is from 4,000 to 30,000 over the center 1067 mils of the search sector and 4,000-22,000 meter over the outside search sectors. Figure 4-19 shows the higher probability coverage areas for cannons.

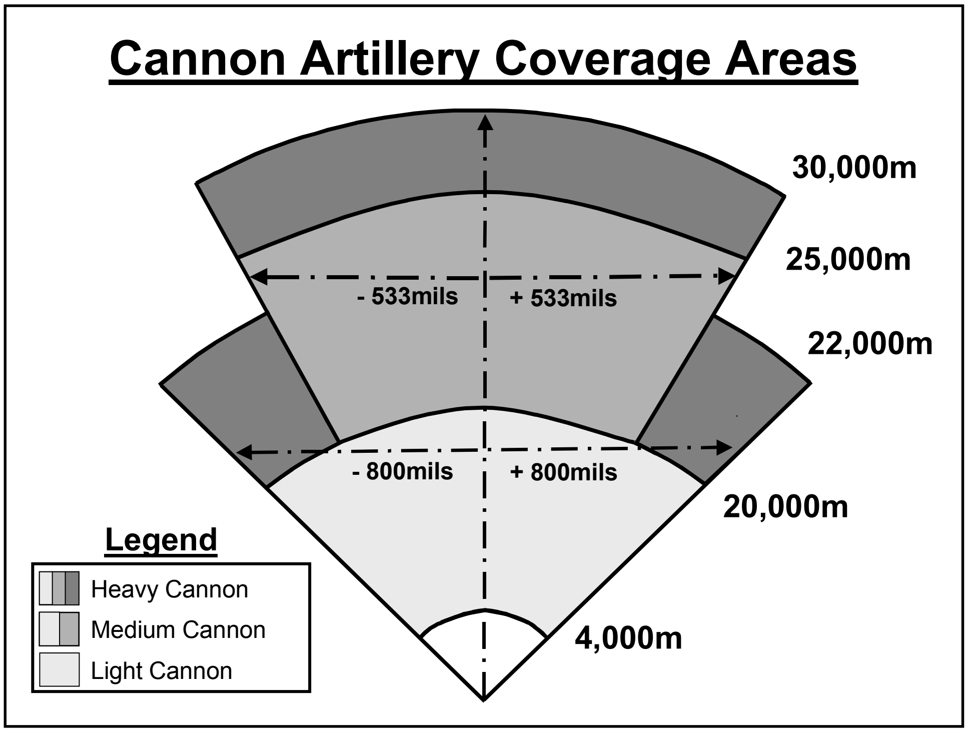


Figure 4-19. Q-37 Cannon Artillery Coverage Areas

The probability of locating long-range rockets up to 762mm in diameter is at least 85% for quadrant elevations greater than 300 mils. The detection ranges are between 4,000 and 50,000 meters over the center 1067 mils of the search sector and 4,000-37,000 meters across the outside search sectors. Figure 4-20 depicts the coverage area for long-range rockets.

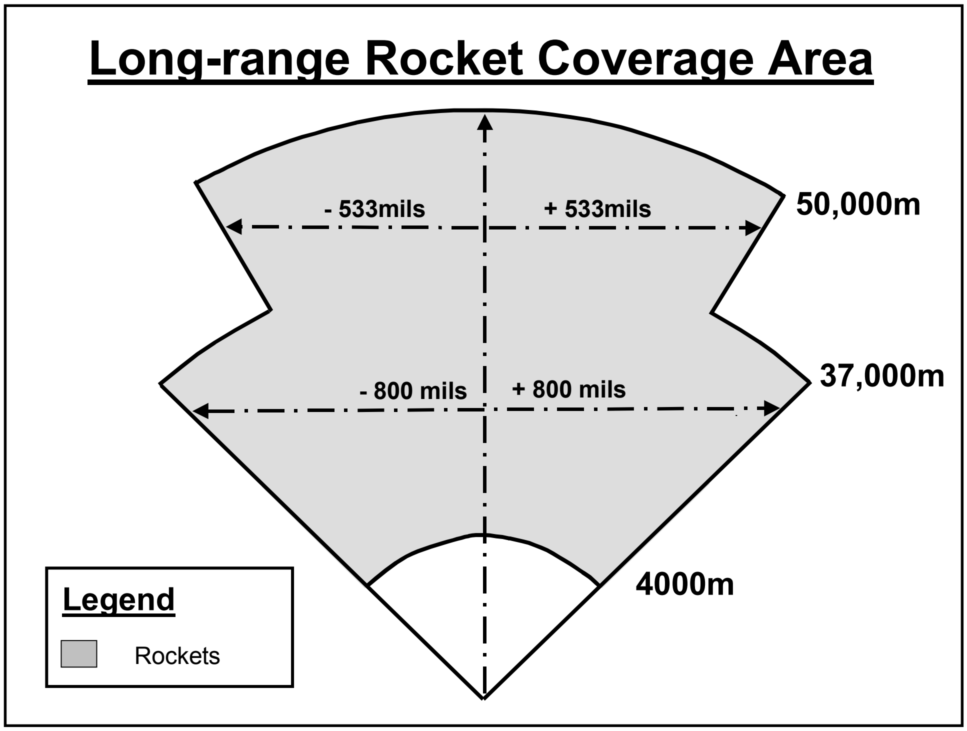


Figure 4-20. Q-37 Rocket Coverage Areas

ACCURACY

The accuracy, or target location error for the Q-37 is characterized in the same manner as for the Q-36. The maximum 50% TLEs by projectile type are:

- All cannon – 35m or .35% of range whichever is greater.
- Long-range rocket – 70m or .4% of range whichever is greater.

The maximum 90% TLEs by projectile type are:

- All cannon – 90m or .9% of range whichever is greater.
- Long-range rocket – 175m or 1% of range whichever is greater.

Table 4-3 provides 50% TLE data and Table 4-4 provides 90% TLE data.

Table 4-3. Maximum 50% Target Location Errors

Target Category	Ranges 4km	10km	20km	22km	25km	30km	37km	50km
Mortar	N/A	N/A	N/A	N/A	N/A	N/A		
Cannon	35m	35m	70m	77m	88m	105m		
Rocket	70m	70m	80m	88m	100m	120m	148m	200m

Table 4-4. Maximum 90% Target Location Errors

Target Category	Ranges 4km	10km	20km	22km	25km	30km	37km	50km
Mortar	N/A	N/A	N/A	N/A	N/A	N/A		
Cannon	90m	90m	180m	198m	225m	270m		
Rocket	175m	175m	200m	220m	250m	300m	370m	500m

SYSTEM COMPONENTS

The AN/TPQ-37(V)8 consists of an operations control group (OCG), antenna transceiver group (ATG), power distribution group (PDG), trailer power distribution unit, M998/M1038 HMMWV and a FMTV for transporting the trailer power distribution unit. Figure 4-21 depicts the major components of the AN/TPQ-37(V)8 system.

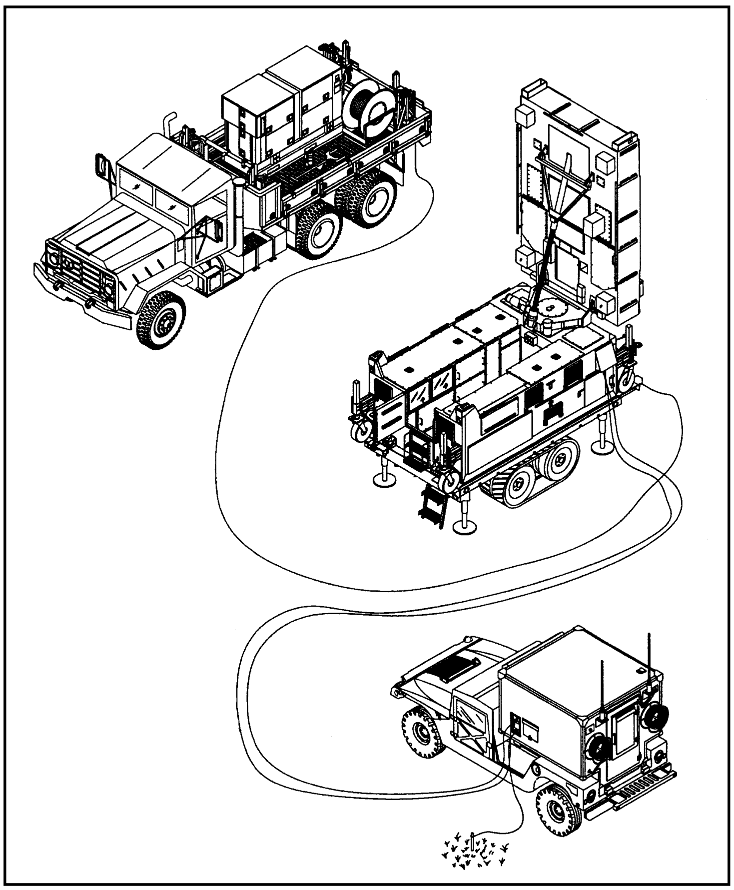


Figure 4-21. The AN/TPQ-37(V)8 Radar System

Operations Control Group

The OCG is the focal point for operating the radar. It consists of a S-250 shelter, a M1097 HMMWV, and the shelter cable set. The shelter contains the computer, printer, signal processor, displays, B-scope, weapons location unit, and the magnetic tape unit. The shelter cable set consists of two 50-foot cables. These cables connect the shelter to the ATG. One cable is a power cable that provides power from the ATG to the shelter. The second cable is a data cable that allows data exchange between the antenna and the shelter. The cables are stored on cable spools attached to the back of the shelter during movement. An alternate method of storing the cables is to place them in the HMMWV bed under the shelter. This allows the cables to remain connected to the shelter during movement. This technique is often used since it shortens the required emplacement time for the radar. Figure 4-22 shows the operations control group.

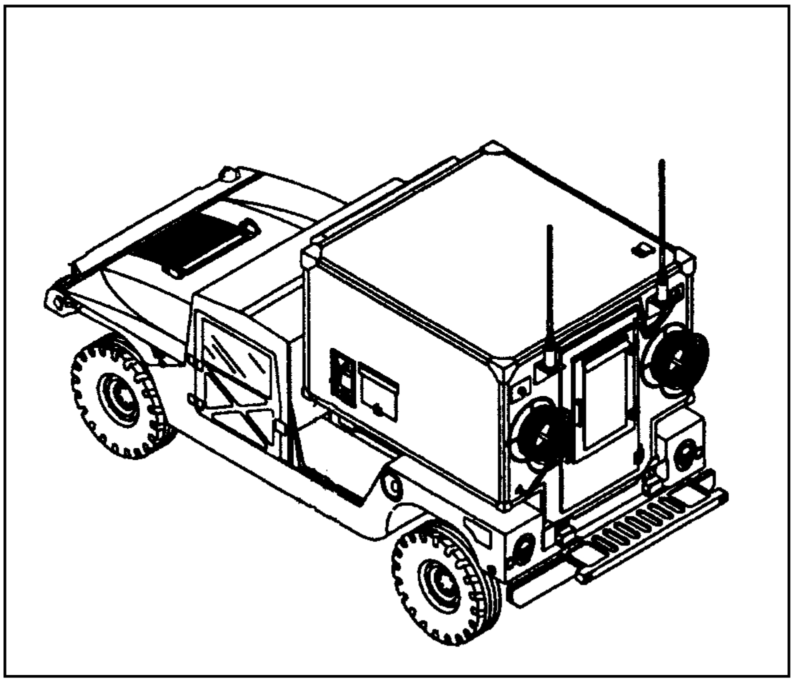


Figure 4-22. Operations Control Group

Antenna Transceiver Group

The ATG consists of the antenna, modular azimuth positioning system (MAPS), a modified M1048A1 antenna trailer and all of the radiating elements and associated feed, receiver preamplifiers and receiver protectors, azimuth and elevation positioning circuits, beam steering circuits, tilt sensor, and boresight telescope. The antenna is erected to the vertical position during operations and lowered to the horizontal position for transport. The PDG 5-ton truck tows the ATG during movement. The modified M1048A1 trailer is equipped with the medium track suspension system (MTSS). The MTSS is designed to improve the mobility of the trailer when traveling over soft soil, sand, mud and snow covered terrain. MAPS is an inertial surveying system designed for use in the ground mobile environment. It provides the radar with an on-board position location and survey capability. MAPS uses a vehicle motion system to determine the location of the radar antenna. MAPS provides the radar with the following information:

- Horizontal position (easting and northing) to the nearest meter.
- Altitude to the nearest meter.
- Grid azimuth to the nearest mil.

Figure 4-23 depicts the ATG.

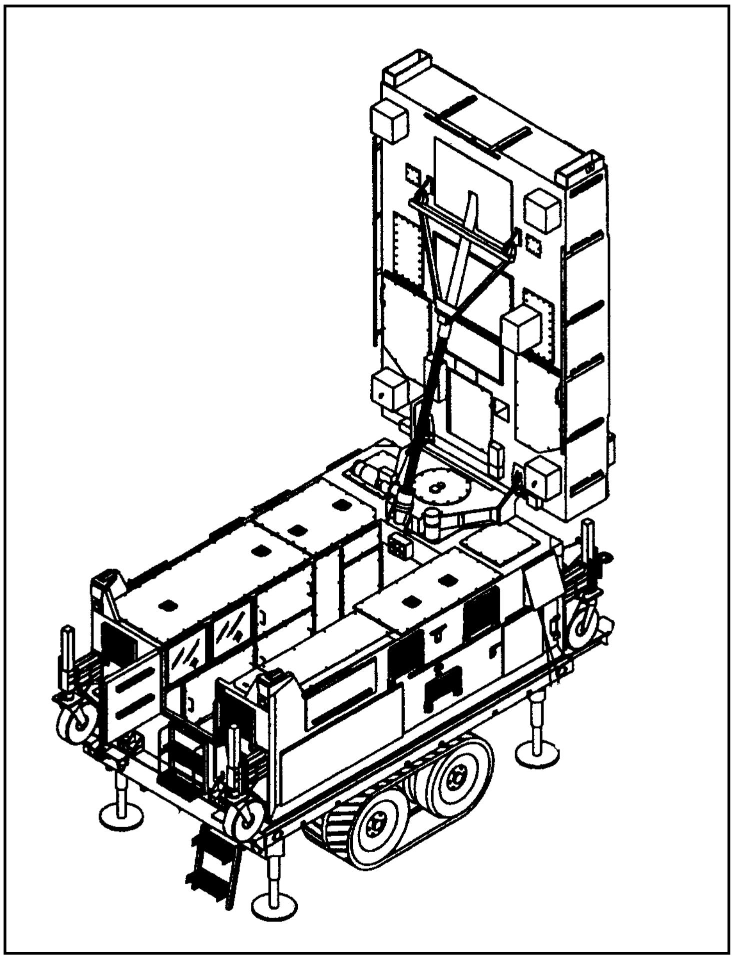


Figure 4-23. Antenna Transceiver Group

Power Distribution Group

The PDG consists of generator pallet mounted on a M923/925 5-ton truck, and the prime power cable. The generator is a 400HZ 600KW precise power tactical quite generator mounted on a special pallet. The prime power cable is contained on a spool that is mounted on the left rear of the generator pallet. The prime power cable is a 32-meter cable that connects the PDG generator to the ATG via a power distribution box with an eight-meter cable. This allows the PDG to be positioned up to 30 meters from the ATG given the requirement for 10 meters of slack in the cable. Figure 4-24 shows the PDG.

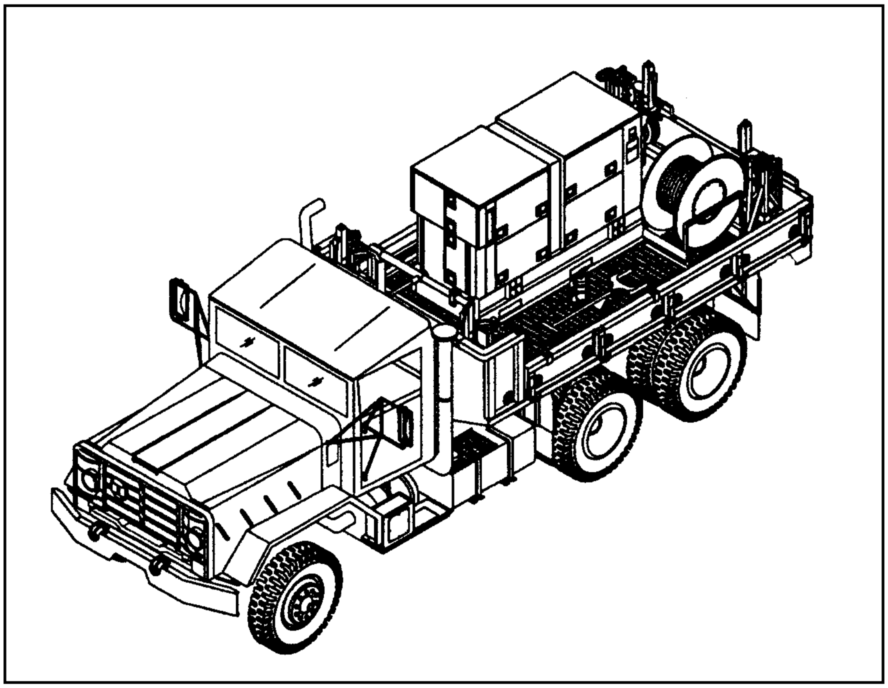


Figure 4-24. Power Distribution Group

Trailer Power Distribution Unit

The trailer power distribution unit (TPDU) is a PU-806 or 400HZ 60KW generator mounted on a M200A1 trailer. The trailer is towed by the FMTV during movement. Figure 4-25 shows the TPDU.

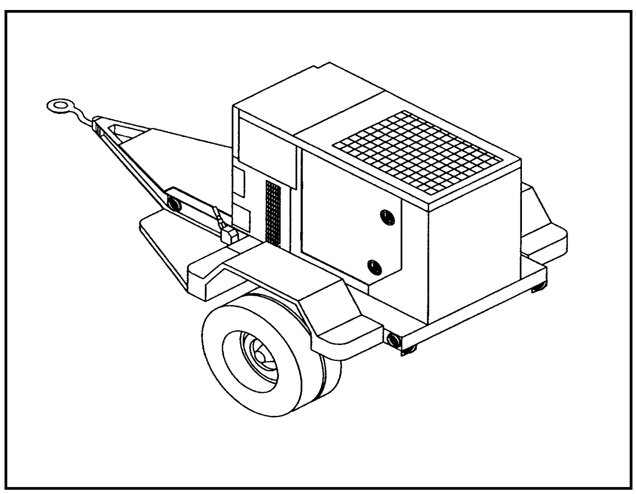


Figure 4-25. Trailer Mounted Auxiliary Generator

AN/TPQ-37 Version Differences

There are currently four versions of the Q-37 in service, the AN/TPQ-37(V)8, AN/TPQ-37(V)7, AN/TPQ-37(V)6, and the AN/TPQ-37(V)5. The upgrade between the version 5 and version 6 radar added Kevlar to the ATG. Version 7 added the modified M1048A1 trailer with MTSS. The major upgrades occurred between version 7 and version 8. The differences between version 8 and previous versions include:

- The operations central (OC) shelter is transported on a M1097 HMMWV instead of an M35A2 2-1/2 ton truck.
- The antenna is mounted on the M1048A1 trailer instead of the M1048 trailer.
- A M925 5-ton truck has replaced the M813 series generator truck.
- The 800 or 900 series cargo truck has been replaced by a medium tactical vehicle (MTV).
- The antenna transceiver group (ATG) contains a modular azimuth positioning system (MAPS).
- The ATG has an improved cooling system.
- The PDG generator pallet and ATG contain wheels that allow the components to be loaded onto C-130 and C141 aircraft without external ground equipment.
- The antenna transceiver group has fragmentation protective plating.
- The antenna contains an upgraded transmitter.
- The radar shelter contains upgraded operations control.
- The radar is Package 11 software compatible.

Figures 4-26 and 4-27 depict the operational configurations of these radars.

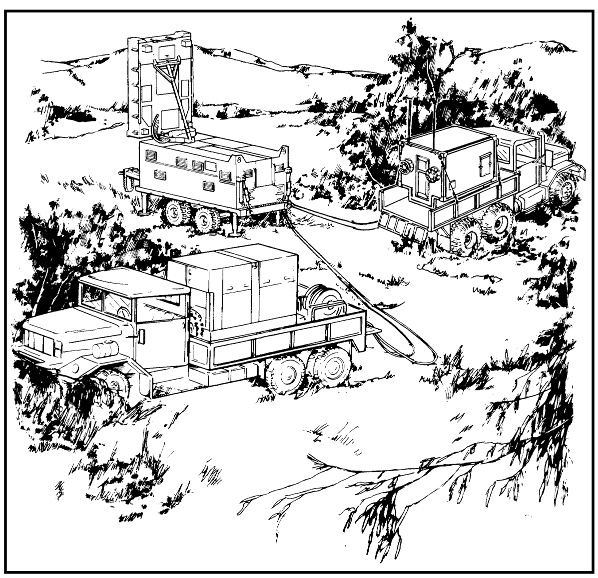


Figure 4-26. Radar Set AN/TPQ-37(V)

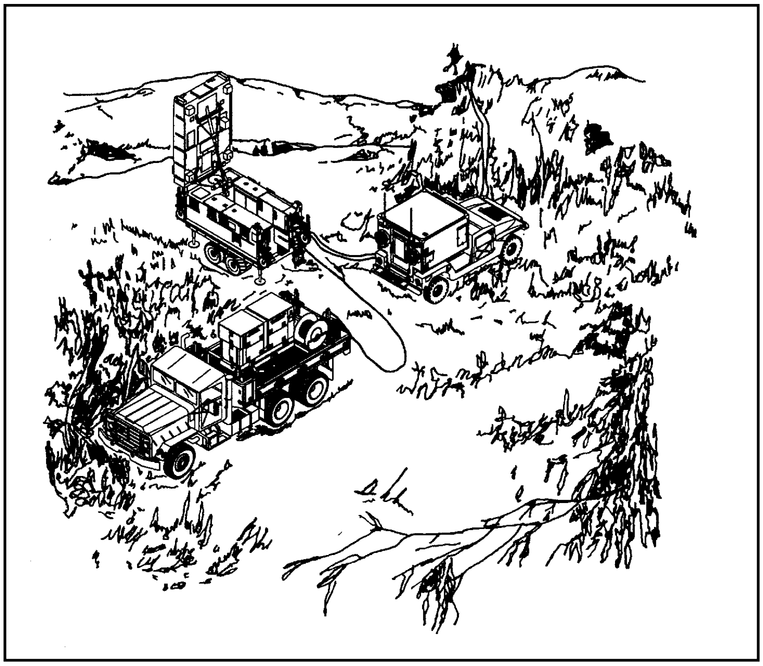


Figure 4-27. Radar Set AN/TPQ-37(V)8

SECTION III – TECHNICAL ASPECTS OF SITE SELECTION, POSITIONING AND OPERATIONS

SITE SELECTION

The technical aspects and characteristics of radars determine the requirements for site selection. The radar section leader selects the actual radar site from the position area(s) identified by the DS field artillery battalion S2 and radar section leader during the MDMP or as designated by the targeting or counterfire officer. The technical considerations for site selection include:

- Slope.
- Area in front of the radar.
- Screening Crest.
- Aspect angle.
- Electronic line of sight.
- Track volume.
- Proximity of other radars.
- Cable lengths.

SLOPE

Slope is an import consideration for the proper positioning of the radar. The slope of the terrain must be 7 degrees (120 mils) or less to ensure proper leveling of the ATG. The ATG will not operate properly without leveling. There are also safety considerations associated with sighting the radar on slopes greater than recommended. Some slope is advantageous and enhances radar functioning. Slope also provides drainage to the radar sight that can help prevent radar components from becoming stuck during periods of heavy or continuous rainfall.

AREA IN FRONT OF THE RADAR

The area in front of the antenna should be clear of foliage that extends above the bottom of the antenna. Radar signals can be attenuated by more that 1 dB per meter of heavy foliage. A few meters of foliage can severely reduce radar effectiveness. A clear area in front of the radar minimizes attenuation of the radar beam. This area should extend 200 meters in front of the radar for the Q-36 and 300 meters in front of the radar for the Q-37. The ideal site will have a clear area in front of the radar that has a gentle downward slope for approximately 200-300 meters and then gradually rises up to the screening crest. This reduces multipath errors. Multipath errors are errors in target location created when radar transmit or return signals travel by more than one path.

SCREENING CREST

A screening crest increases the survivability of the radar by serving as a defense against enemy observation (visual and infrared), direct fire, and electronic countermeasures. The screening crest also helps attenuate sound. Ideally, the screening crest should be in friendly territory and located approximately 1000 meters in front of the radar, perpendicular to the radar's azimuth to center sector. The vertical angle to the screening crest should be between 15 and 30 mils for the Q-36 and 5 and 15 mils for the Q-37. The optimum vertical angle is 10 mils. Further, the difference between the highest and lowest points on the screening crest should not exceed 30 mils. A difference of more than 30 mils reduces the ability of the radar to produce enough track volume to compute a weapon location or impact predict point. The vertical angle between the radar antenna and the top of the screening crest is called a mask angle. Appendix F contains a detailed discussion of mask angle.

ASPECT ANGLE

The aspect angle is the angle between the radar beam and the target path. The aspect angle must be more than 1600 mils in hostile mode and between 800 and 1200 mils (angle-T) in friendly mode. Since the radar is a doppler radar, a target moving directly away or directly toward the radar produces the greatest change in frequency and a more accurate target location.

ELECTRONIC LINE OF SIGHT

The overriding consideration in the selection of a radar site is electronic line of site. The radar must have electronic line of sight (ELOS) to the projectile being detected to acquire the weapon. However, ELOS to the weapon is not required. The radar technician should verify ELOS before occupying the site.

This can be done manually or with the Firefinder Position Analysis System. Verifying ELOS before occupying a radar site can save valuable time by eliminating untenable radar sites prior to their occupation.

TRACK VOLUME

Track volume is the amount of vertical coverage required by the radar to detect a projectile and compute a solution. The track volume is determined by the vertical scan of the radar and the amount of vertical scan lost because of the terrain contour, or screening crest in front of the radar. Firefinder radars require 50 mils of track volume to detect a projectile. Further, the difference between the high and low mask angles should not exceed 30 mils. A detailed discussion of track volume is contained in Appendix F.

PROXIMITY OF OTHER RADARS

Other radar systems or active emitters can interfere with radar coverage by attenuating or jamming the radar beam. Radars and emitters close in proximity or azimuth of search may cause jamming. Inadvertent jamming can be avoided by careful planning of radar positions.

CABLE LENGTHS

Cable lengths must be considered when selecting a radar site. The cables determine the maximum extent to which the components of the radar can be dispersed. The location of system components is determined by terrain contour, foliage, site access, and threat. Ideally, the radar components should be positioned to take advantage of naturally available cover and concealment. Nonetheless, cable lengths may dictate the actual positions. Table 4-5 provides a consolidate listing of cable lengths for the Q-36.

Table 4-5. Q-36 Cable Lengths

Cable	Length (m)
Prime Power Cable	32m (105 ft.)
ATG Power Cable	8m (26 ft.)
Shelter Power Cable	50m (164 ft.)
Shelter Data Cable	50m (164 ft.)

Based on these lengths, the Q-36's OCG can be placed up to 40 meters from the ATG and 30 meters from the PDG. The remote CDT can be located up to 90 meters from the shelter when using both CDT cables. Emplacement of system components must allow for 10 meters of slack in the cables to prevent damage to cable heads and connectors. Table 4.6 shows the cable lengths for the Q-37.

Table 4-6. Q-37 Cable Lengths

Cable	Length (m)
Prime Power Cable	40m (131 ft.)
Auxiliary Power Cable	40m (131 ft.)
CDT Cable (x2)	50m (164 ft.)
Shelter Power Cable	50m (164 ft.)
Shelter Data Cable	50m (164 ft.)

Based on the cable lengths in Table 4-6, the Q-37 OCG can be placed 40 meters from the ATG. The PDG can be placed up to 30 meters from the ATG given the combined lengths of the prime power and ATG power cable. The requirement for 10 meters of cable slack also applies to the Q-37.

SITE ACCESS

The radar site should have more than one route of approach. Routes of approach should be accessible by section vehicles, free from enemy observation, and capable of being guarded by a minimum number of personnel. The quality of access must also be considered. Some essential considerations include:

- Accessibility during poor weather conditions. Can the position be accessed during periods of rain and snow? Positions that may deteriorate during inclement weather should be avoided to prevent stranding the radar.
- Overhead clearance. Avoid locations where trees, power or telephone lines may damage radar components when entering and exiting the position. Check the clearance requirements for tunnels and overpasses to ensure section equipment does not exceed requirements.
- Bridges. Check the bridge classifications on routes to radar positions. Ensure that the bridge classification of section equipment does not exceed the load bearing capabilities of the bridge.
- Fords. Check fords to ensure they are passable to the radar section equipment. The ATG for the Q-36 and Q-37 can only ford 30 inches of water. If heavy rains are expected some positions may become untenable because of fording restrictions.
- Obstacles. Check routes for current and planned obstacles. These obstacles may include road craters, tank ditches, abates, or wire obstacles. Also check for natural obstacles such as fallen trees and rockslides. Ensure that the access is sufficient to allow egress after combat has occurred. Rubble from buildings, utilities and fallen trees should not prevent the radar section from displacing from a position.

POSITIONING

Positioning is based on the technical requirements and capabilities of the radar and tactical considerations. The overriding factor in positioning is mission accomplishment. Mission, enemy, terrain, troops, time available, and civil considerations (METT-TC) are paramount when selecting radar positions. The DS battalion S2 in conjunction with the targeting officer or controlling FA headquarters designates general position areas for radars. The radar section leader selects the actual radar site within the position area.

TACTICAL CONSIDERATIONS

Radar position areas are selected based on IPB, the range capabilities of the radar, and METT-TC. A through analysis of METT-TC will dictate which factors are most important. Generally, in a traditional battlespace, radars are positioned far enough from the FLOT to acquire enemy weapons, prevent loss of the radar to enemy action, and avoid unnecessary movement. This maximizes radar coverage and cueing time. Given the radar's minimum range and the necessity to avoid conflicts with maneuvering friendly forces, the Q-37 is normally positioned 8-12km from the FLOT and the Q-36 3-6km behind the FLOT. This rule of thumb may change based on the tactical situation. In stability and support operations, radars may be positioned inside an intermediate staging base (ISB) or enclave.

Mission

Radars must be positioned where they can best accomplish their mission. Several factors drive positioning in relation to mission considerations. The supported unit, commander's guidance, associated command and support relationship, and required sector of search dictate in general where the radar must be positioned. The requirements to conduct hostile and friendly operations add specificity to positioning requirements. Further, the requirements to establish priority zones influence radar positioning.

Enemy

The enemy situation and capabilities greatly influence where a radar must be positioned. A through IPB is essential to determining radar locations. IPB influences positioning in two ways. First, IPB identifies the areas where enemy systems are anticipated. This information and the commander's targeting guidance dictate the positioning and orientation of the radar. Further, IPB identifies enemy threats that must be considered when positioning the radar. These threats may include suspected locations of ground threats or special purpose forces, electronic warfare threats, major ground and air avenues of approach, and anticipated requirements for repositioning.

Terrain (and Weather)

Terrain effects movement, cover, concealment, communications, and positioning. In mountainous terrain, identifying positions that maximize the radar's range and capabilities is difficult. A position with an optimum screening crest may be difficult if not impossible to find. Terrain may also narrow the search sector because of inadequate electronic line of sight. On the other hand, flat or open terrain makes concealment difficult. Heavy rains, snow, sand storms, and dust storms can attenuate the radar signal and degrade the probability of location. Heavy rains and snow can make some terrain impassable or the soil unstable. The effects of terrain and weather upon positioning must be considered or mission accomplishment will be jeopardized.

Troops

The size of the area to be covered and the number of radars available affect both positioning and employment. When multiple radars are available to support a unit, smaller search sectors may be assigned to specified radars. Further, positions should be selected that facilitate mutual support between radars. This allows one radar to assume all of or part of another radar's search sector and priority zones during displacement and movement. The number of crewmembers assigned to a radar section can also affect positioning. Sections manned at less than authorization may require additional support to accomplish the mission. This support may include security or maintenance above normal levels. Co-locating or positioning the radar in the vicinity of another unit may be required.

Time Available

The time available for reconnaissance, liaison, movement, occupation, and position improvement must be considered. Mission requirements and the amount of time available to position radars may require that a radar initially position in a less than optimum position then reposition at a later time as mission requirements dictate.

Civil Considerations

Civilians in the battlespace may impact positioning and radar operations. Positioning requirements may include additional security considerations when there is a hostile local populace. In addition to direct threats, movement routes may become blocked or congested by the local populace, refugees, or obstacles. However, a cooperative or friendly populace may enhance positioning options. Fixed facilities or other civil structures may become available for use by the radar section. Local logistical support may also be available.

OTHER CONSIDERATIONS

Cover

When possible, section equipment should be placed in a defilade, hardened structure or prepared position to protect the radar and crew. This provides the crew and some equipment with protection from hostile fire. Even so, the radar's ATG cannot be completely covered. The ATG can only be placed in a location that provides cover to the top of the ATG trailer. This provides protection for the ATG electronics while providing an unobstructed line of sight for the antenna. Placing the radar in a covered position also helps dissipate noise from the ATG and PDG, lowers susceptibility to direct observation, and reduces the radar's thermal and infrared signatures. In situations where a defilade or prepared position is unavailable, the radar crew should consider burying the radar data and power cables. The data cable is one of the most vulnerable components of the radar system. It is susceptible to damage by indirect fires or by a vehicle driving over the cable. One broken or damaged wire in the cable can render the cable useless. The power and data cables should be buried in hand-dug trenches six inches deep, 12 inches deep when crossing roads. The trench should be free of rock and debris, as should the soil used to fill the trench. Engineer equipment should not be used to fill the trench because damage may occur to the cables and excess soil compaction may prevent recovery of the cables during radar displacement.

Concealment

Maximum use of natural concealment, such as trees and shrubs, should be considered in selecting a sight for the radar. Care should be taken to avoid obstructions in front of the antenna that might attenuate the radar beam. Buildings and other manmade structures can be used to conceal some section equipment. Concealment is also affected by where the radar site is located. The unit's IPB should identify likely enemy observation points. When possible, radar sites should be selected that avoid direct observation from these areas.

Communications

Communications between the radar and the supported unit will normally be conducted using FM digital and/or voice communications over SINCGARS or EPLRS. Electronic line of sight is required for FM communications. Radar positions must have adequate line of sight to facilitate FM communications with the supported unit. Further, radar positions must be in range of the organic communications or retransmission support must be provided

RECONNAISSANCE

The radar section leader conducts reconnaissance of general positions areas received from the controlling FA headquarters and selects actual radar positions. The reconnaissance will normally include a map reconnaissance, a site analysis using the FireFinder Position Analysis System (FFPAS), and a ground or air reconnaissance if time permits. At a minimum, a map reconnaissance and FFPAS analysis should be conducted. FFPAS is an excellent tool. However, it cannot replace the information gained from an actual ground or air reconnaissance. An actual reconnaissance is invaluable in determining the conditions in the position area and along movement routes.

MAP RECONNAISSANCE

The map reconnaissance is used to determine the following:

- Tactical situation in the position area. This requires a thorough review of the situational template and operational graphics. This review should identify contaminated areas, obstacles, minefields, known friendly and enemy locations, enemy observation posts, and enemy avenues of approach.
- Routes into and out of the position area.

- Identifying landmarks that can aid in hasty survey and navigation.
- Bridges, fords and bypasses leading into and out of the position area.
- Possible ambush and controlling terrain sites.
- Units that may be operating in the vicinity that may assist with security or medical assistance.
- Tentative radar sites for ground reconnaissance.
- Inter-visibility lines that may provide screening crests.
- Contour lines to provide information about ground slope.
- Significant terrain features that may enhance survivability or degrade radar performance.
- Possible alternate positions.

FFPAS ANALYSIS

Once tentative radar sites are determined, FFPAS is used to analyze the suitability of the site. FFPAS can provide the following information:

- Screening crest.
- Mask angle.
- Electronic line of sight.
- Optimum search fence.
- Estimated performance of the radar.
- Slope of the terrain.

GROUND RECONNAISSANCE

A ground reconnaissance should follow the map reconnaissance to determine passability of movement routes, validate position suitability, and facilitate the rapid occupation of the position. The ground reconnaissance is based on the factors of METT-TC and the technical and tactical considerations that influence radar operations. During the ground reconnaissance the radar section leader or section chief should accomplish the following:

- Determine routes of ingress and egress to the position area.
- Search and mark the area for obstacles and mines.
- Determine alternate positions and rally points.
- Determine the exact locations for the ATG and OC.
- Select a location for the PDG that minimizes its effects on operations.
- Determine vehicle locations that facilitate displacement.
- Measure and evaluate the screening crest.
- Obtain survey control to support MAPS/GPS requirements.
- Provide local security.

SURVIVABILITY CONSIDERATIONS

Survivability of the radar must be considered when selecting radar positions. Radars are susceptible to enemy ground attack, air attack, indirect fires and electronic warfare. A through IPB will identify possible threats.

GROUND AND AIR ATTACK

The radar section can take precautions to protect itself against ground and air attacks. The best protection against a direct attack is to position the radar in areas that prevent direct observation by enemy forces. This is important since most attacks by indirect fire or special purpose forces are initiated as a result of direct observation. Positioning outside of known enemy avenues of approach and air axes of advance will help avoid attack by enemy ground and air forces. Security measures may include dedicated maneuver forces or military police to provide on-site protection, or mutual support provided by units in the vicinity of the radar position. Mutual support arrangements might consist of early warning or incorporation of the radar in the supporting unit's defense plan. In addition, the radar section can protect itself by using cover and concealment. Selecting positions with natural or existing manmade cover and concealment is best. Engineer assets may also be tasked to provided prepared positions.

ELECTRONIC WARFARE

The radars electromagnetic signature makes it susceptible to electronic attack and radio direction finding (RDF). Standard signal security procedures can reduce the radar vulnerability to RDF. Detection by air and ground-based EW systems may present a greater problem. The IPB will identify known EW threats to the radar. Possible EW threats may include the IL-20 COOT (air), NRS-1, and NRS-X (ground systems). These systems are found in former Soviet-bloc countries. Selecting sites that lower the radar's electronic signature helps protect the radar against ECM threats.

Occupy Optimum Sites

The best countermeasure to enemy EW is to occupy optimum sites. An optimum site is one in which the radar is emplaced on level terrain having a gentle downward slope for the first 200-300 meters in front of the radar then a sharp rise to a screening crest.

Screening Crest

The use of a screening crest is critical when an enemy has ECM capabilities. The screening crest diffracts the radar beam making if difficult to determine the direction of the radar beam.

Double Screening Crest

The use of two screening crests makes the radar more difficult for the enemy to locate. The second crest further diffracts the radar beam making it more difficult to accurately locate the radar.

Tunneling

Tunneling is the technique of reducing the side, top, and back lobes of radiation by careful site location. Tunneling is accomplished by sighting the radar where vegetation is located to the sides and rear of the radar antenna. Tunneling may also be accomplished by digging-in or sandbagging the position. The use of tunneling will reduce vulnerability to direction finding of side lobe radiation.

Orient on Soft Background

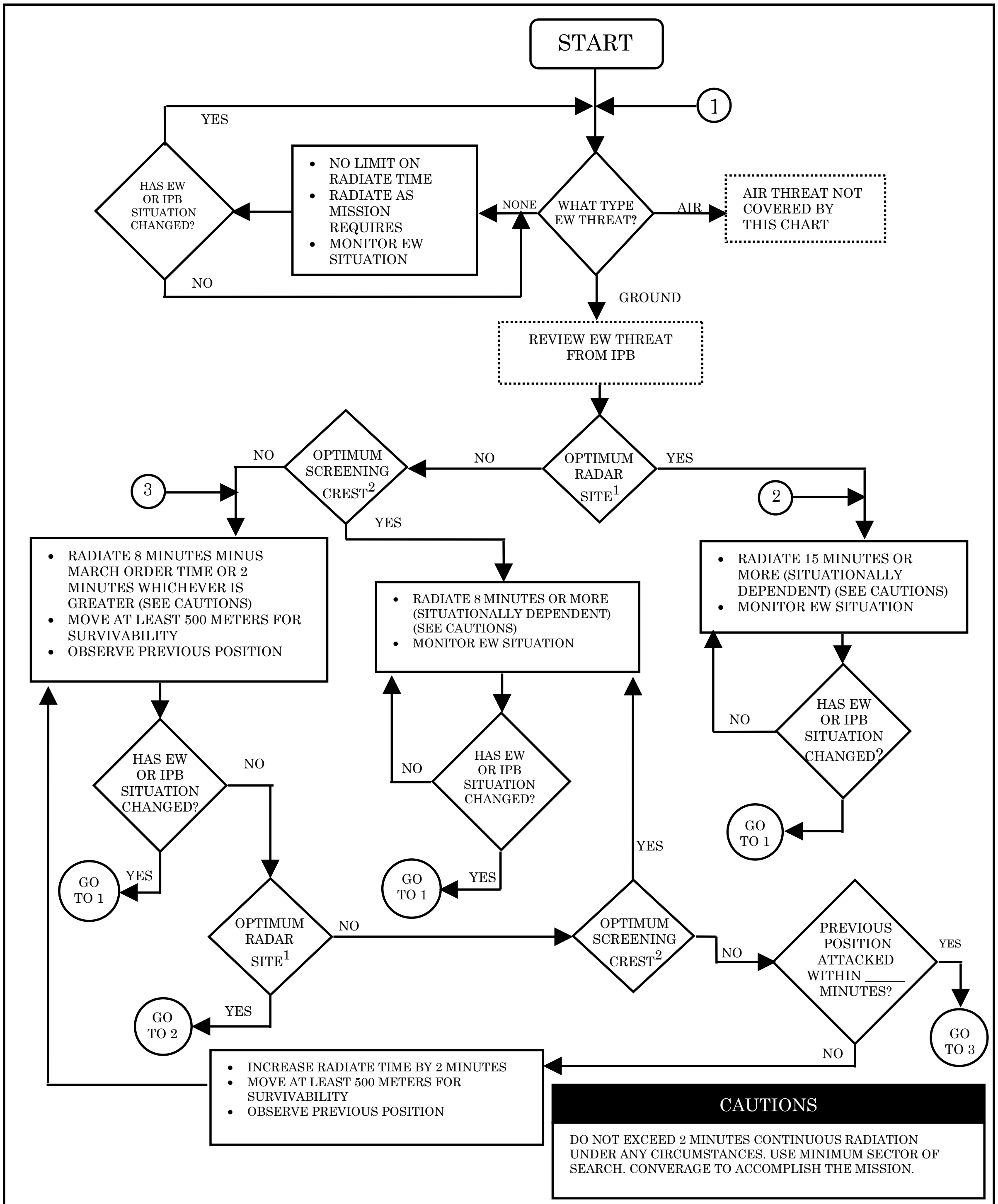
If there are no terrain features or vegetation to reflect or absorb the radar beam beyond the target area, the background is open. Unrestricted access to non-reflected radar beams is an ideal situation for enemy DF operators. Orienting on a soft background such as foliage, tree lines or brush reflects the radar beam and makes it more difficult to DF. Hard backgrounds such as rock, buildings, bunkers or other structures also reflect radar beams. However, soft backgrounds are better than hard backgrounds. The reflection of radar beams causes a phenomenon known as the multipath effect. During reflection the beam is bent and phase shifting occurs. This results in the same signal being received from multiple directions and out of phase making the signal more difficult to DF. The optimum background is an open background above a screening crest.

Reduce Radiating Time

The shorter time the radar transmits the lower the probability that the enemy will DF and obtain a fix on the radar. Transmission time should be reduced based on the enemy's detection capabilities to prevent being acquired. As a general rule, continuous radiation time should not exceed two minutes when the enemy has ECM capabilities. The radar survivability matrix in Table 4-7 can be used as quick reference to determine the total amount of radiation time from a position. Total radiation time should be adjusted based on the tactical situation. In situations with no ECM threat, continuous radiation should be the norm. The survivability flow chart in Figure 4-28 provides a detailed process for evaluating the electronic threat and determining total radiating time.

Table 4-7. Survivability Matrix

RADAR	SCREENING CREST	TUNNELING	EW THREAT (AIRBORN THREAT NOT COVERED)	RADAR POSITION HAS SCREENING CREST AND TUNNELING	RADAR POSITION HAS SCREENING CREST ONLY	RADAR POSITION HAS NEITHER SCREENING CREST NOR TUNNELING
WEAPONS LOCATING RADAR AN/TPQ-36	• WITHIN 1,000 METERS OF RADAR POSITION • IN FRIENDLY TERRITORY • FROM 15 TO 30 MILS ENEMY CANNOT ACHIEVE ELECTRONIC LINE OF SITE WITH HIS DIRECTION-	USE OF FOLIAGE, BERM, OR BUILDINGS TO REDUCE SIDE-LOBE RADIATION	GROUND EW THREAT REVIEW WITH S2 CURRENT EW THREAT TO FIREFINDER	ACCUMULATE 15 OR MORE MINUTES OF RADIATION -but-	ACCUMULATE 8 OR MORE MINUTES OF RADIATION -but-	RADIATE 8 MINUTES MINUS MARCH-ORDER TIME OR 2 MINUTES WHICHEVER IS GREATOR; MAKE SURVIVABILITY MOVE -but-
				DO NOT EXCEED 2 MINUTES OF CONTINUOUS RADIATION		
			NONE	• NO EW TIME LIMIT • RADIATE AS MISSION REQUIRES • MONITOR EW SITUATION		
WEAPONS LOCATING RADAR AN/TPQ-37	• WITHIN 1,000 METERS OF RADAR POSITION • IN FRIENDLY TERRITORY • FROM 15 TO 30 MILS ENEMY CANNOT ACHIEVE ELECTRONIC LINE OF SITE WITH HIS		GROUND EW THREAT REVIEW WITH S2 CURRENT EW THREAT TO FIREFINDER	ACCUMULATE 15 OR MORE MINUTES OF RADIATION -but-	ACCUMULATE 8 OR MORE MINUTES OF RADIATION -but-	RADIATE 8 MINUTES MINUS MARCH-ORDER TIME OR 2 MINUTES WHICHEVER IS GREATOR; MAKE SURVIVABILITY MOVE -but-
				DO NOT EXCEED 2 MINUTES OF CONTINUOUS RADIATION		



[1]Optimum radar site definition: AN/TPQ-36 screening crest 15 to 30 mils: AN/TPQ-37 screening crest 5 to 15 mils: good tunneling effect in foliage to reduce side lobe radiation.

[2]Optimum screening crest definition: within 1,000 meters of your position and in friendly territory: no crest in enemy territory higher then yours that is within the enemy's normal direction finding operating range.

Figure 4-28. Survivability Flowchart

Operating Through Electronic Countermeasures

Operating through electronic countermeasures consists of detecting the presence of jamming or interference and performing actions to minimize or eliminate the effects of jamming.

Q-36. The radar indicates jamming by displaying a vertical line at the jamming azimuth on the operational display, by a printed jam strobe message, the INTFR/JAM indicator being lit on the operations screen, or for some types of jamming, displaying many short duration tracks on the monitor. To avoid degradation of radar performance the following tactics may be used:

- Turn on the radar's electronic counter countermeasures (ECCM) feature.
- Avoid operation within line of sight or in the same sector as the jammer.
- Operate on a different frequency than the jammer.
- Use deception.

Turning on the radar's ECCM functions allows the operator to activate the jam strobe and pulsed interference rejection functions. The jam strobe identifies jamming and identifies the azimuth of the jamming while pulsed interference rejection helps filter out interference from the jammer. If pulsed interference rejection doesn't work the other tactics can be implemented. Line of sight issues can be avoided by selecting optimal radar sights. Relocating a radar to avoid jamming may or may not be possible based on the tactical situation. Changing radar frequencies will sometimes help avoid the jammer's operating frequency. Increment frequencies one at a time and determine from the jam strobe indicator if the jammer is still present. Increase the frequency, starting at the lowest frequency, the least amount necessary to avoid degrading the radar's performance. If these steps don't work, it may be possible to fool the jammer by ceasing to radiate for a few minutes. Change frequencies then resume operations. This may help prevent the jammer from staying on the radar's operating frequency.

Q-37. The tactics for working through ECCM for the Q-36 are applicable to the Q-37. Further, the Q-37's jam strobe and pulsed interference rejection functions are similar to the Q-36. In addition, the Q-37 has a clear channel sensing (CCS) function. CCS is automatically turned on when the radar's operational program is entered. CCS passively scans the radar's 49 search beam positions using all 15 frequencies of each beam position and determines which frequencies are free of jamming or interference. A frequency report is provided to the operator. During operations, the CCS function disables frequencies and provides operator alerts based on the radar frequency mode in use. There are three frequency modes. They are:

- Single frequency.
- Diversity (the normal operating mode).
- Electronic countermeasures avoidance (ECMA).

In single frequency mode, the radar operates on a single frequency for all beams. If jamming is detected on the frequency, CCS activates the

DEGRADED/PRFM warning light indicating the radar is operating in a degraded mode. In diversity mode, a different frequency is used for each beam position. Up to five frequencies can be selected by the operator for each beam position. When operating in diversity mode, CCS disables individual frequencies within beam positions to avoid jamming. When only one frequency remains and it is not clear, CCS activates the DEGRADED/PRFM warning light. Finally, the radar can be operated in the ECMA frequency mode. This mode is used to combat ECM when ECM is seriously degrading the radar's performance. It should only be used under this condition because ECMA mode degrades the radars performance. In this mode, radar frequencies and beam positions are selected at random.

ANTIRADIATION MISSILES

Antiradiation missiles (ARM) can pose a significant threat to radars. US ARM employment uses the AGM-88 High speed Antiradiation Missile (HARM). Coalition Forces also employ the Alarm, Armat, AS-6, AS-9, AS-11 and AS-16. (Note: HARM and ARM can be used interchangeably, but the US exclusively uses the term HARM.) ARMs are of particular concern because friendly aircraft may inadvertently attack a radar (or "emitter") if unaware of its presence and operating frequencies. For example, if aircrews are unaware that an AN/TPQ-36 is radiating in the aircraft's area of operations it may be engaged as a possible SA-6 radar and attacked. Further, coalition aircraft may not have the ability to discriminate between enemy and friendly radar signatures exacerbating the risk to friendly radars. Danger to friendly radars may occur during situations where JSEAD is employed in support of deep maneuver operations, aerial interdiction or when receiving close air support. Coordination of radar information during the planning process can reduce the risk to friendly radars. The targeting technician must ensure that location is constantly updated and this information is passed to the battlefield coordination detachment (BCD). The Corps EWO must be cognizant of all emitters found on the battlefield, friendly, neutral and threat. The electronic order of battle (EOB) must include all emitters and be constantly updated to prevent a fratricide incident. It is imperative that the planners ensure that all radar locations are identified and disseminated. Pertinent information about radar in the AO can be submitted with the air support request for preplanned missions and passed directly to the aircraft by the ALO during terminal control of CAS. Information submitted for preplanned missions is analyzed at the air operations center (AOC) and aircraft rules of engagement (ROE) are developed and published in the airspace control order (ACO) and the special instructions (SPINS) of the air tasking order (ATO). The following information, as a minimum, must be passed to AOC via the BCD to deconflict radar operations and ARM employment:

- Radar type and purpose.
- Radar location.
- On-air/off-air times.
- Emitter parametrics.
- Frequency range.
- Pulse repetition frequency (PRF).

- Pulse repletion interval (PRI).
- Pulse width.
- Scan type/rate.
- Site specific patterns.
- Physical site set-up.
- Communications capabilities.
- Coordination frequencies and call signs.

If radar and ARM missions cannot be deconflicted, emitter shut down techniques must be used during ARM employment. This process can be tedious and time consuming. Preplanned CAS missions normally allow sufficient time to coordinate shutdown. However, during immediate CAS missions this may not be the case. The supported ground commander must balance the risk of fratricide with the need for SEAD to support immediate CAS. In some cases, the ground commander may decide it is neither tactically sound, nor possible, to quickly and effectively shut down friendly emitters. TTP for the employment of ARM are contained in FM 90-35, Multiservice Procedures for Antiradiation Missile Employment in a Joint Environment. Table 4.8 contains the Q-36 and Q-37 radar technical parameters for deconflicting radar operations and ARM employment.

Table 4-8. Radar Operational Parameters

Parameter	Q-36	Q-37
Radar Type	Pulse Doppler	Pulse Doppler
Frequency Range	9.37 – 9.99 Ghz	3.1 – 3.39 Ghz
PRF	7692.3 – 14,705 pps	2793.3 – 5050.1 pps
Pulse Width	1 millisecond	10.75 milliseconds
Modulation Type	Chirped pulses	Chirped pulses
Peak RF Power Output	73.6 dBm minimum	120 kW min
Duty Cycle	0.012	0.041

LOCATION AVERAGING

Location averaging is a functional part of the radar operational program that eliminates duplicate targets and prevents the loss of targets by eliminating backlogs in the radar's temporary display queue. This function is automatically turned on when the radar's operational program is loaded. Nonetheless, location averaging can be turned off if a requirement exists to identify target locations in close proximity to one another.

When a target is located it is placed in the temporary target queue pending operator action. Targets remain in the temporary queue until the operator stores or transmits the target. Storing or transmitting the target removes the target from the temporary queue and places the target in permanent storage. This frees space in the temporary queue. If the temporary queue becomes full, all further target acquisitions are lost until space is freed in the temporary queue. Location averaging automatically frees space in the temporary queue by averaging new targets with targets in permanent storage. If a new target is within 200 meters of a target in permanent storage, the radar will automatically average its location with the target in permanent storage, update the stored target's location, and remove the new target from the temporary input queue. This saves space in the input queue, eliminates duplicate targets, and saves permanent storage space. If the new target does not correlate with a stored target, it is placed in the temporary input queue pending operator action. Figure 4-29 demonstrates the concept of location averaging.

LOCATION AVERAGING

- **Purpose: To prevent overloading the radar's storage queue with acquisitions from the same location.**
- **When location averaging is turned on, the radar averages all detections from the same 200 meter radius into one single grid location.**

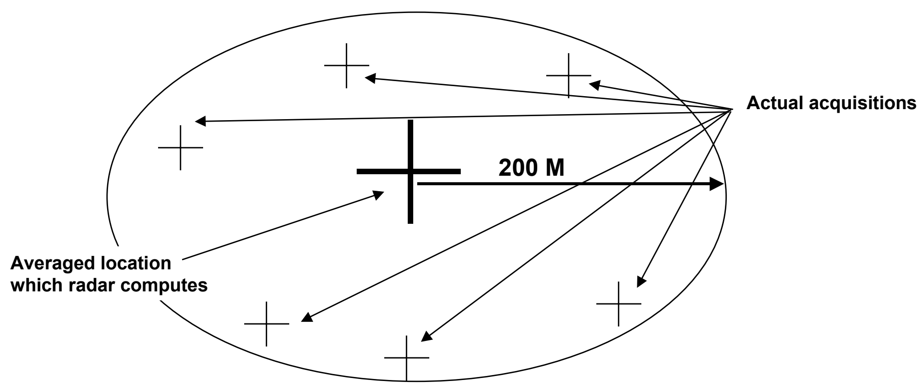


Figure 4-29. Location Averaging

AUTOMATIC HEIGHT CORRECTION

Height correction is an essential function that must be performed to accurately locate enemy weapons. Height correction is required because the radar thinks the altitude of the target is the same as the high or low datum plane depending on which was used to initialize the radar's computer. Without height correction the radar will locate a hostile weapon by backtracking the trajectory until it intersects the datum plane used during initialization instead of using the actual terrain altitude. This can cause a significant error in target location.

The radar automatically performs height correction when digital terrain data is available, accurate, and loaded into the system. In the absence of digital terrain, manual height correction must be used. Figure 4-30 demonstrates the importance of height correction.

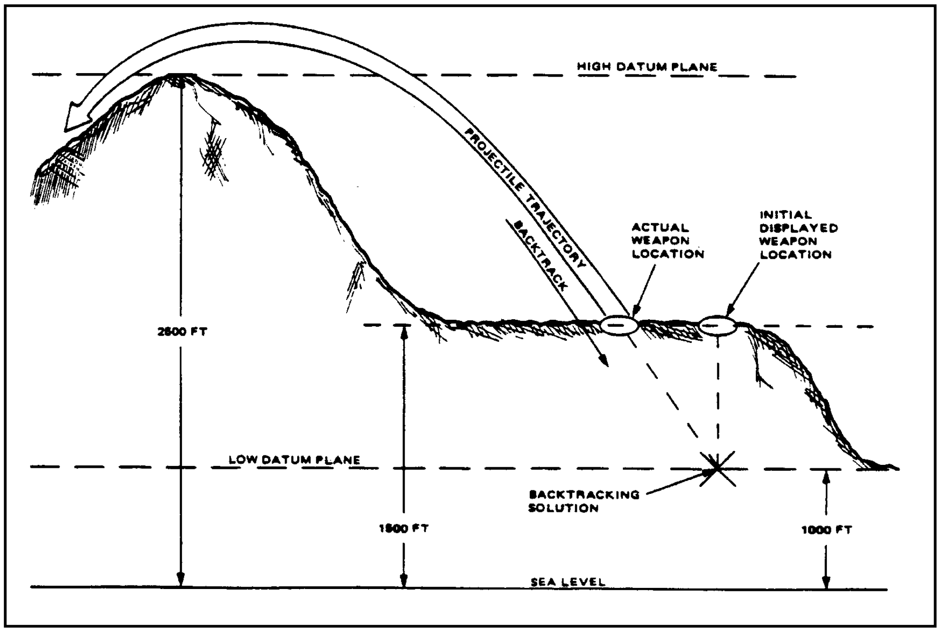


Figure 4-30. Height Correction Example

In the example shown in Figure 4-30, the initial height in the height display is 1000 feet (the height of the low datum plane), whereas the actual weapon location height is 1500 feet. Therefore, the weapon location indicated on the site map will be incorrect, and the height of this location will not agree with the height indicated by the height display. If the correct weapon location height of 1500 feet is known, it can be entered directly. When the new height is entered, the backtracking solution moves along the projectile trajectory to the intersection with the new height and that new point becomes the displayed weapon location. When the height of the location indicated on the site map and that indicated by the height display agree, no further height correction is required and the displayed location is correct.

AUTO CENSORING

The radar's auto censoring function is used during anticipated periods of heavy enemy fire or when the radar begins locating more than 10 targets per minute. Auto censoring maximizes the radar's ability to locate new firing positions, saves computer-processing time and saves space in the permanent target list. It accomplishes this by eliminating duplicate target tracks that exceed a specified threshold count. When auto censoring is on, the radar examines each new track for proximity to an existing weapon location. If the new track is within 500 meters of a known target, and exceeds the established threshold count, the track is dropped. The threshold count is the maximum number of tracks allowed from a know location. It can be set from 2-16 tracks. Normally, a lower threshold count is established during periods of higher enemy fire. Care must be exercised when using auto censoring since this function causes the radar to ignore acquisitions.

FIREFINDER POSITION ANALYSIS SYSTEM

The FireFinder Position Analysis System (FFPAS) is a computer tool that facilitates the sighting and set-up of radars. FFPAS determines radar coverage at a particular location by assessing the radar's ability to locate different types of enemy weapons. FFPAS is capable of performing, in minutes, calculations that require significantly more time when done manually. The rapid analyses capability of this computer-based system allows the radar section leader to quickly analyze alternative sites and evaluate potential radar coverage. FFPAS significantly reduces the time required to perform a detailed radar site analysis.

SITE ANALYSIS

The radar site is evaluated by specifying the position in the terrain database. The radar operator positions the radar in FFPAS by specifying the position's easting, northing and local reference datum on a pop-up menu. On a second menu, the antenna's mechanical azimuth boresight, left and right sector scan limits, and its minimum and maximum coverage ranges are specified. This information is used to construct a terrain plot. Figure 4-31 shows an example terrain plot.

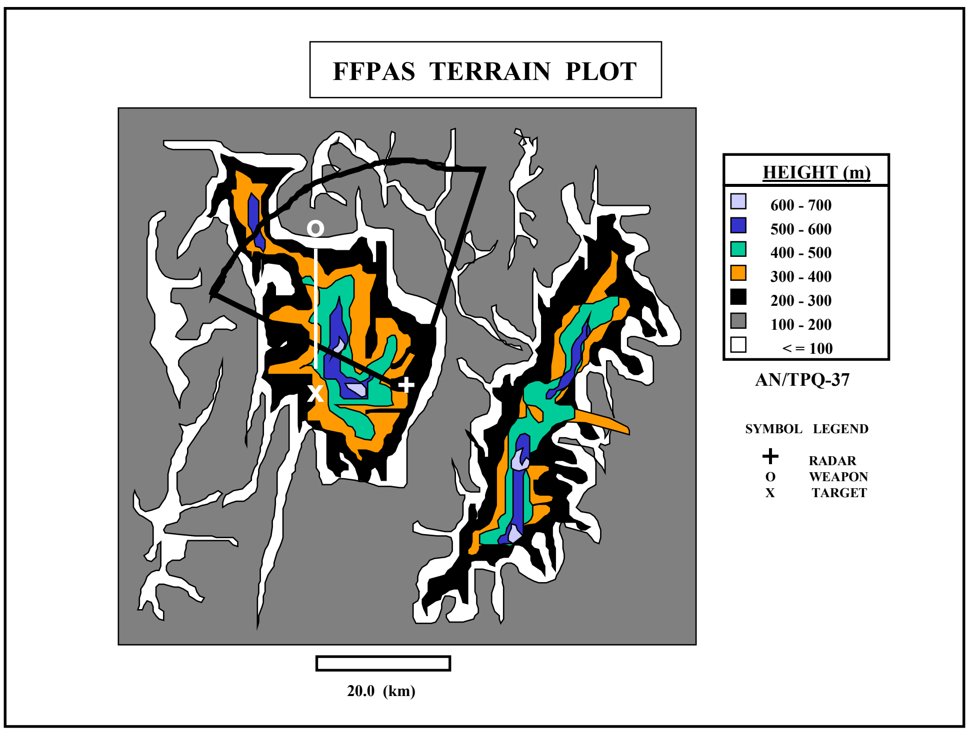


Figure 4-31. FFPAS Terrain Plot

The white "+" at the center of this figure denotes the radar location, while the annular wedge depicts the radar coverage zone for the selected site. The terrain plot provides the operator with a topographic map of the area around the radar. The color code can be quickly changed to match the height characteristics of the local terrain or those of a small area on the terrain plot.

By clicking on a particular point, the easting, northing and altitude of that point are provided to the user. The user can also magnify a region of this plot by placing a rectangle zoom box around a desired area. The user can now produce several additional plots to evaluate the radar sighting, any or all of which can be active simultaneously. The screen angle plot shown in Figure 4-32 shows a terrain profile.

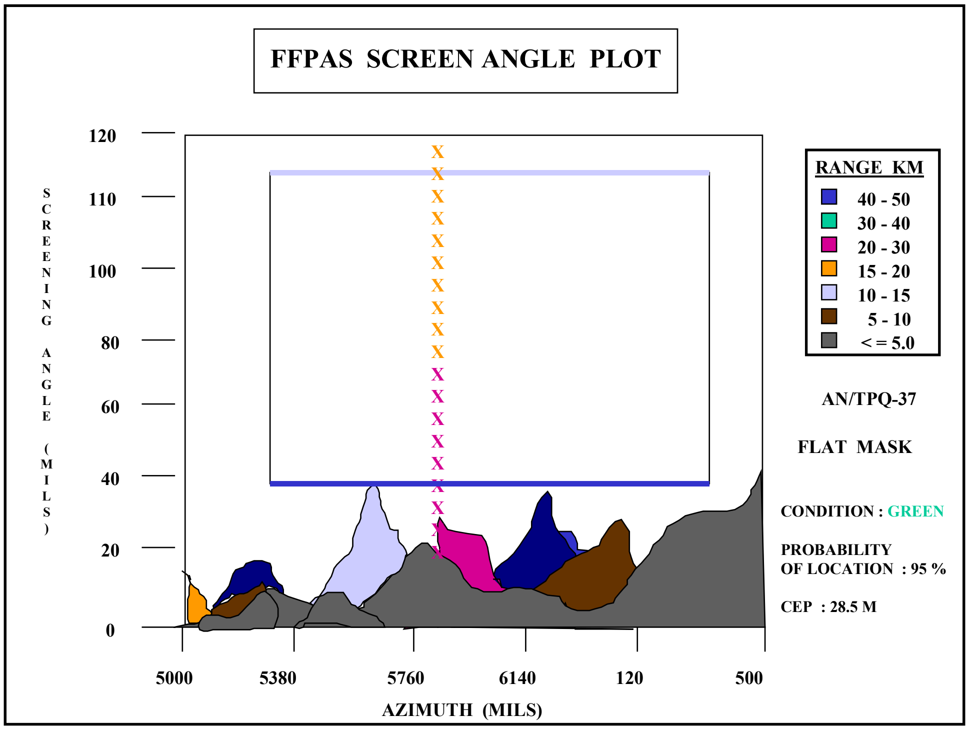


Figure 4-32. Screen Angle Plot

The screening crest as a function of range can be obtained directly from this plot. The range to the terrain is color-coded. The rectangular box on this plot denotes the left and right azimuth scan limits and the upper and lower elevation scan limits.

Figure 4-33 shows a clutter plot. This plot shows where radar returns from stationary objects can degrade radar performance.

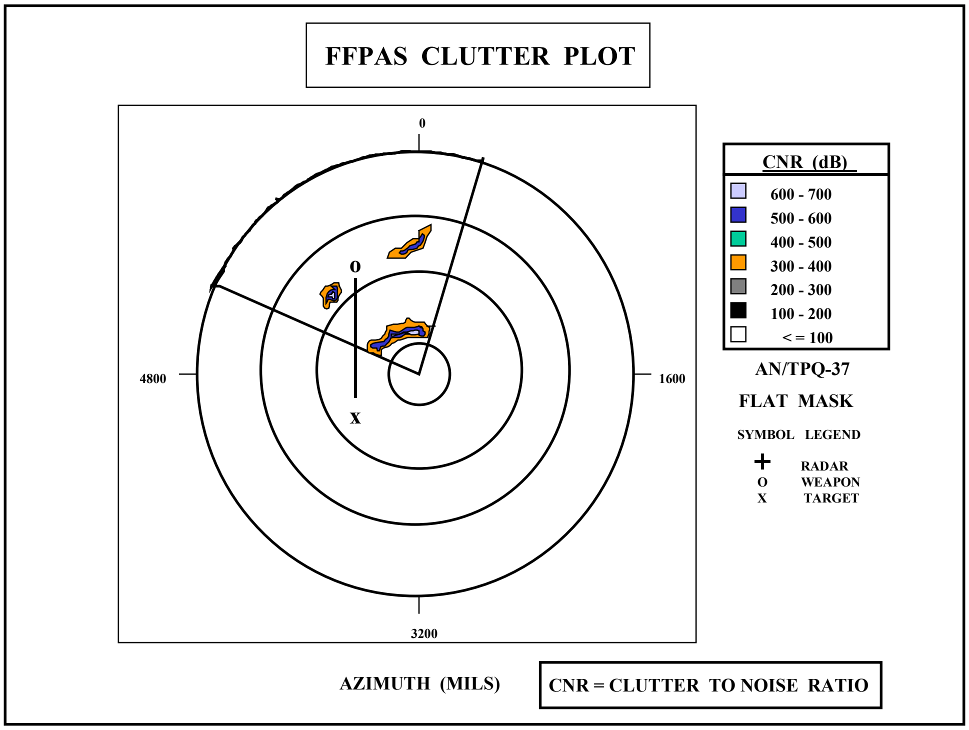


Figure 4-33. Clutter Plot

Weapon Location Analysis

FFPAS provides the ability to perform a computer analysis of the radar's performance against probable enemy weapon location and aim points. This allows the operators to assess the radar's sighting and set-up based on battlefield intelligence in a variety of scenarios. FFPAS accomplishes this task by first allowing the user to specify the weapon type, location and aim point, and both the quadrant elevation (QE), and muzzle velocity for a shot, and then by estimating the ability of the radar to determine the location of the weapon.

FFPAS models several generic weapon types, including mortars, light, medium and heavy artillery, and both light and heavy rockets. Also, specific weapon types can easily be included in the system. FFPAS will inform the operator if the shot parameters that have been input are not within the capabilities of the weapon. For achievable shot's, all relevant data (e.g., the distance from the weapon to the impact point, the range from the radar to both the weapon and the impact point, etc.) are displayed. The system automatically computes the minimum QE values. The operator may then change the muzzle velocity or the QE value to analyze other firing conditions. The maximum QE can be obtained at the push of a button.

The weapon model parameters used in FFPAS include the allowable range of values for muzzle velocity, atmospheric drag coefficients, and the radar cross-sectional area (RCS) of the projectile as a function of its aspect angle. This ensures the projectile's trajectory is correctly modeled and the radar signal strength is accurately determined. Once a shot has been specified, it can be overlaid onto all FFPAS plots.

Four additional pieces of information are provided to the operator on FFPAS plots. They are:

- P (Solution): The probability that the radar will collect a sufficient amount of data with a suitable target to interference ratio (TIR) to solve weapon location equations.
- CEP: The circular error probable for the weapon location estimate.
- P (Location): The probability that the CEP will be within the radar's specification.
- Condition Color: A simple means for characterizing the radar performance through a green/yellow/red/black color code. The condition color has been designed to give the user a rapid means of assessing the sighting evaluation, especially under stressful conditions. A thorough assessment of the results can then be performed when time permits.

In addition to the data above, tabular data describing the radar characteristics for both the projectile and the environment are provided for each point along the simulated trajectory.

SAFETY CONSIDERATIONS

Safety is an important consideration when operating and working around Firefinder radars. Possible safety concerns include radiation, wind, noise and electrical hazards.

RADIATION

When the radar transceiver is energized, it poses a microwave radiation hazard to personnel. The radiation hazard area for the AN/TPQ-36 radar extends 5 meters in front of the antenna within a 1600-mil fan about the boresight for all transmitting operations. For narrow-sector azimuth scan angles less than 400 mils, an additional sector must be controlled to a distance of 30 meters from the antenna. For fixed-beam mode, the hazard area extends to a distance of 75 meters in front of the radar. The narrow-scan hazard sector usually applies to friendly fire mode operations and fixed-beam to certain maintenance operations. In addition, microwave radiation may cause the accidental detonation of some types of live ordnance out to 268 meters, especially those electrically armed or detonated. If the radar is to be emplaced near an airfield or ammunition site, liaison should be made with the organizations responsible for the operations of those facilities. Microwave radiation poses the same types of safety hazards for the AN/TPQ-37. However, the microwave radiation produced by the AN/TPQ-37 poses a safety hazard at increased ranges. The hazard area for the AN/TPQ-37 extends 7 meters in front of the antenna within a 1600 mil fan about the boresight for all transmitting operations. For narrow-sector scan, an additional sector must be controlled out to 40 meters. For fixed-beam mode the hazard area extends out to 100 meters in front of the radar. Like the Q-36, the hazard area for electrically armed or detonated explosives is 268 meters from the antenna for the full 1600 mil sector of scan.

WIND

Because of the large surface area of the AN/TPQ-36 antenna, high wind velocity can cause serious safety hazards. Whenever wind velocity reaches a constant 52 mph or gusts up to 75 mph during operations, the antenna must be placed in the stowed position. When non-operational, the radar must be stowed when winds reach 65 mph with gusts to 100 mph. Camouflage nets also should be lowered or removed to prevent damage to equipment or injury to personnel. The same hazards exist for the AN/TPQ-37. However, the radar must be stowed when the wind velocity reaches a constant 40 mph with gusts up to 75 mph during operations. When non-operational, the antenna must be stowed when winds reach 80 mph with gusts up to 119 mph.

OTHER HAZARDS

Other hazards include noise and electrical hazards. Using hearing protection when working around power generation equipment can mitigate noise hazards. Finally, overhead power lines and improper grounding of radar equipment can cause electrical hazards. To prevent these hazards, radio antennas should be tied down during movement and position areas should be selected that eliminate overhead electrical hazards. Further, section equipment must be properly grounded during operation.